1 # MULTI-PROTOCOL WIRELESS COMMUNICATION

2 ## APPARATUS AND METHOD

3 ### Field Of The Invention

4   The invention is directed to a wireless communications apparatus and method.

5 In particular, the invention is directed to a multi-protocol, scaleable wireless switching

6 platform and method.

7 ### Background

8   Wireless communications in the United States were initially conducted solely

9 through analog systems and protocols. The most prevalent analog protocol remains

10 the Advanced Mobile Telephone System (AMPS) protocol. To handle wireless

11 communications and to allow interconnection with traditional wired land-lines,

12 switching systems and base stations were required. The analog switching systems are

13 large and are designed to cover large markets and handle large volumes of calls.

14   In the 1990's digital systems and protocols began to be used for wireless

15 communications. Examples of digital protocols are the Global System for Mobile

16 Communication (GSM) code division multiple access (CDMA), and time division

17 multiple access (TDMA). When wireless networks began to switch to digital

18 protocols, they could not simply upgrade their analog base stations to digital. New

19 equipment for the digital facilities was required. However, the networks continued to

20 use large switching systems designed to cover their large spread markets. Examples

21 of large switching systems are AT&T's 5ESS® system and the AXE system made by

22 Ericsson. The 5ESS® switch is described in detail in the AT&T Technical Journal,

23 Vol. 64, No. 6, part 2, July/August 1985, pages 1305-1564.

24   Large switching systems are designed to cover large markets and to handle

25 many thousands of customers. The larger systems have the advantage of being able to

26 provide a wide range of call options, such as call forwarding, caller identification and

27 call waiting. The switching systems are expensive, however and, therefore, may not

28 be appropriate for small markets and wireless providers. Additionally, large switching

29 systems can be inefficient because of the added additional cost for increased back

30 hauls of calls.

1   Typical switching systems employ proprietary architectures that use hardware

2   components for switching, external interfaces, operating system, and control.

3   Summary Of The Invention

4   A multi-protocol mobile switching center (MSC) provides wireless

5   communications for mobile devices operating on a local wireless network according

6   to any standard protocol including those of the Global Systems for Mobile

7   Communications (GSM) standards and IS-41 standards (including time division

8   multiple access (TDMA), code division multiple access (CDMA), and Advanced

9   Mobile Telephone System (AMPS)). The MSC may be incorporated onto a single

10   platform having a home location register (HLR) and an authentication center (AC or

11   AuC), as well as a visitor location register (VLR) and an equipment identity register

12   (EIR).

13   The multi-protocol MSC is scalable so that it may be used for a small number

14   of customers, such as in a rural setting to provide telephone access, or as part of an in-

15   building communications network. The scalable, multi-protocol MSC may also be

16   used to construct a large, distributed wireless network. Thus, the scalable, multi-

17   protocol MSC provides the flexibility to be used with a wide range of customer bases,

18   and within a variety of different typographies.

19   Because the MSC can process wired and wireless calls according to any

20   protocol, a single switching center may serve customers who operate mobile and fixed

21   communications devices, regardless of protocol. This true multi-protocol

22   functionality makes this switching solution extremely efficient and cost effective, and

23   eliminates the need for separate, protocol-specific components.

24   The multi-protocol MSC can be housed in a standard chassis. The multi-

25   protocol MSC can use standard, off the shelf hardware for most data storage and

26   processing functions. The multi-protocol MSC can be easily updated to take

27   advantage of industry advances by simply replacing select components in the chassis.

28   The multi-protocol MSC provides full-featured telephone and data services,

29   including wired and wireless analog and digital telephony, conference calling, prepaid

1   calling, emergency call routing and long-distance resale. The multi-protocol MSC

2   also provides pocket switching applications such as asynchronous transfer mode

3   (ATM).

4   The multi-protocol MSC incorporates advanced graphical user interfaces

5   (GUIs) that display system data in a convenient, easy to access format. A system

6   operator can quickly select data for display, and can easily modify selected data

7   entries. The system operator can control operation of the multi-protocol MSC using

8   the intuitively structured GUIs.

9   The multi-protocol MSC may incorporate a number of sophisticated features

10   in addition to the HLR, VLR, EIR and the authentication center. These features

11   include an operations and maintenance center, wire line and tandeming services, and

12   hot (real-time) billing and prepaid services.

13   When used for distributed switching, the multi-protocol MSC may reduce

14   build out and operational costs associated with large switching centers. This

15   architecture also eliminates needless back hauling by switching local calls locally.

16   Finally, the architecture allows for add on as a wireless customer base expands.

17   The multi-protocol MSC includes a first interface that receives digital and

18   analog communication according to a first protocol and a second interface that

19   receives digital communication according to a second protocol. The first and the

20   second interfaces include inter system (system-to-system) message handlers and

21   intra system (within system) message handlers.

22   The hardware and software architecture of the MSC is designed to use generic

23   signaling as much as possible to provide call connection and other functions.

24   Protocol-specific communications are handled at a device handler (lower) level, and

25   higher level processing uses generic messaging. A table may be used to map

26   messages of the different protocols to the generic messages used by the MSC. The

27   hardware of the aircore system is based on off-the-shelf industry standard components

28   for each of the four areas typically found as proprietary in current systems. The use of

1   off-the-shelf standardized switching components, interface boards, operating system

2   and control processing provide a unique evolution path for the aircore system.

3   The HLR and VLR are structured so that data that does not depend on a

4   specific protocol is stored in a common memory portion while protocol-specific data

5   is stored in protocol specific portions of the HLR and VLR. This logical arrangement

6   of the HLR and VLR provides for quick access to data by components of the MSC

7   and allows for easier updating by a system operator.

8   An advanced intelligent message (AIM) handler interfaces with the VLR and

9   the HLR to determine the current location and identification of mobile units homed on

10 the HLR or roaming in the local wireless network. The AIM also determines the

11 protocol applicable for the mobile unit. For calls received at the MSC from a local

12 wireless network base station, the protocol determination may be made by reference to

13 the protocol of the base station. For multi-protocol base stations, the determination

14 includes decoding information provided in the service request or similar message sent

15 by the base station. For other mobile units, the MSC may communicate with external

16 wireless components such as other HLRs, VLRs, and MSCs.

17   The MSC includes an authentication and registration system that controls

18 registration of mobile communications devices operating on the system controlled by

19 the MSC. The authentication and registration system also provides encryption and

20 ciphering of voice and data communications.

21   The MSC can also be used as an adjunct to a private branch exchange (PBX)

22 to create an in-building wireless network. Used as such, the MSC and HLR can be

23 used to route calls preferentially among mobile units and fixed telephones and other

24 communications devices.

25 Brief Description Of The Drawings

26   The invention will be described in conjunction with the following figures, in

27 which like numbers refer to like features, and wherein

28   Figures 1a - 1d show wireless communication environments according to the

29 invention.

1   Figure 2 is a block diagram of an aircore switching platform.

2   Figure 3 shows a wireless loop architecture.

3   Figure 4 shows a fixed wireless loop architecture.

4   Figure 5 shows the aircore platform with local area mobility.

5   Figure 6 shows the aircore platform with system level mobility.

6   Figure 7 shows the aircore platform with full scale mobility.

7   Figure 8 shows a wireless network architecture.

8   Figure 9 is a block diagram of aircore functions.

9   Figures 10 is a block diagram of the aircore software architecture.

10   Figure 11 is a block diagram of the advanced intelligent message handler

11 architecture.

12   Figure 12 is a block diagram of the A-interface message handler.

13   Figure 13 is a block diagram of the ISDN user part message handler.

14   Figure 14 is a block diagram of a intersystem message handler.

15   Figure 15 is a block diagram of a device handler for voice input-output

16 devices.

17   Figure 16 is a block diagram of a device handler for digital interfaces.

18   Figure 17 is a block diagram of a device handler for ISDN interfaces.

19   Figure 18 is a block diagram of a device handler for signaling system 7

20 communication.

21   Figure 19 is a block diagram showing software interlayer communications.

22   Figure 20 is a logical representation of the home location register.

23   Figure 21 illustrates the HLR/VLR database structures.

24   Figure 22 is a block diagram illustrating the location management feature of

25 the visitor location register.

26   Figure 23 is a state machine for mobile originated call processing.

27   Figure 24 is a state machine for PSTN originated call processing.

28   Figure 25 is a state machine for mobile terminated call processing.

29   Figure 26 is a diagram of a near end facility state machine.

1   Figures 27 is a diagram of a far end facility state machine.

2   Figure 28 is a diagram illustrating mobile unit hand off.

3   Figure 29a shows the software components used for call processing.

4   Figure 29b shows the object structure for the aircore call processing.

5   Figure 29c is a flow chart illustrating an authentication process.

6   Figures 30-34 are flow charts showing message signaling associated with

7   interface maintenance.

8   Figures 35-40 are flow charts showing message signaling associated with trunk

9   management.

10   Figures 41-47 are flow charts showing message signaling associated with

11   mobility management.

12   Figures 48-66 are flow charts showing message signaling for call processing.

13   Figures 67-71 are flow charts showing message signaling associated with call

14   processing with an external HLR.

15   Figures 72 is a flow chart showing message signaling associated with hand off

16   pre-processing.

17   Figure 73 is a logical diagram of a prepaid rating system.

18   Figure 74 is a flow diagram illustrating emergency call processing.

19   Figure 75 is a block diagram illustrating first party call control.

20   Figure 76 is a block diagram illustrating third party call control.

21   Figures 77-79 are block diagrams of call delivery methods using third party

22   call control.

23   Figure 80 is a block diagram of an in-building wireless communications

24   network.

25   Figures 81-84 are block diagrams of an embodiment of the aircore platform

26   hardware architecture.

27   Figures 85-86 are block diagrams of another embodiment of the aircore

28   platform hardware architecture.

1   Figures 87-123 illustrate graphic user interface screens for use with the aircore

2   platform.

3   <u>Detailed Description Of The Invention</u>

4   Mobile telecommunications (radio) systems that permit customer calling from

5   mobile stations such as automobiles, or small light weight hand held personal

6   communications units are becoming increasingly prevalent. These systems use the

7   principles of cellular technology to allow the same frequencies of a common

8   allocating radio bandwidth to be reused in separated local areas or cells of a broader

9   region. Each cell is served by a base transceiver station comprising a group of local

10   transceivers connected to a common antenna. Base station systems, each including a

11   controller and one or more transceiver stations, are interconnected via a switching

12   system, called a mobile switching center (MSC), which is also connected to the public

13   switched telephone network (PSTN), and the Public Land Mobile Telephone Network

14   (PLMN). These mobile telecommunications systems are now entering a second

15   generation characterized by digital radio communications with a different set of

16   standards, such as the European Global System for Mobile Communications (GSM)

17   standard promulgated by the Special Mobile Group (SMG). The GSM standard is

18   also being adapted for use in the United States. In addition, in the United States,

19   CDMA, TDMA, DAMPS, and AMPS are used for digital cellular mobile

20   communications.

21   The mobile telecommunications systems have many components that need to

22   communicate signaling information for controlling the establishment of connections.

23   Such signaling information is communicated over channels that are separated from the

24   channels carrying actual voice or data communications between the connected

25   customers. Among the components that need to communicate to establish voice and

26   data communication links are the mobile units, the base station system connected by

27   radio to the mobile units, the mobile switching center and the various databases that

28   are consulted for the establishment of mobile calls. These databases include a home

1   location register (HLR) with an authentication center (AC (IS-41) or AuC (GSM)), a

2   visitor location register (VLR), and an equipment identification register (EIR).

3   Signaling messages among these components are processed by many

4   expensive protocol handlers. In the past, these protocol handlers were too expensive

5   to permit incorporation into a single unit. Modern switching systems typically include

6   expensive MSCs, such as AT&T's 5ESS® switch. These systems only make sense for

7   deployment when there are a large group of mobile customers who will use the

8   system.

9   This invention uses advanced signal processing, a novel method of structuring

10   signal processing software and an enhanced home location register/visitor location

11   register to provide multi-protocol, scaleable mobile telecommunications capability.

12   The software architecture is specifically designed so that generic processing is used to

13   the maximum extent possible to process signals and data related to different digital

14   and analog protocols including GSM, TDMA, CDMA and AMPS, and proprietary

15   protocols.

16   Figure 1a shows a general arrangement of a mobile telecommunications

17   environment 100. At the heart of this environment 100 is an aircore platform 200 of

18   the invention. The aircore platform 200 receives messages from, and transmits

19   messages to a variety of fixed and mobile sources, conforming to each of the protocols

20   employed by the sources.

21   Base transceiver stations (BTSs) 110 receive messages from and transmit

22   messages to the aircore platform 200 over land lines 113. The land lines 113 may be

23   any telecommunications medium that is capable of high speed data transmission, such

24   as fiber optic cable, T-1 and E-1 lines and coaxial cable, for example.

25   The BTS 110 transmits messages to and receive messages from mobile and

26   fixed sources. In Figure 1a, the BTSs 110 are shown in wireless communication with

27   mobile phones 112, a mobile phone in a car 116 (a roaming mobile phone), a

28   microcell 115, and a wireless local loop 150. The wireless local loop 150 may include

1   several connections. The wireless local loop 150 is described in more detail below. A

2   telephone 118 may operate in conjunction with a private branch exchange (PBX).

3   The BTSs 110 may operate in conjunction with the fixed and mobile sources,

4   according to one of several wireless protocols as set forth above.

5   The aircore platform 200 communicates with a public switched telephone

6   network (PSTN) 120 via a wired path 121 and with a wireless network 130 via a

7   signal path 131.

8   The aircore platform 200 also communicates with a satellite 141 via a satellite

9   receiver 140.

10   Figure 1b shows a GSM wireless environment 101. The aircore platform 200

11   connects to the BTS 110 via a base station controller (BSC) 105. Mobile units 112,

12   the roaming mobile phone 116, the wireless local loop 150 and the microcell 115

13   communicate by way of wireless radio channels with the BTS 110. The aircore

14   platform 200 also connects to a GSM MAP network 133 via landline 132 and to the

15   PSTN 120 via the landline 121. Finally, the aircore platform 200 communicates with

16   the satellite 141 via the antenna 140.

17   Figures 1c and 1d show wireless environments 102 and 103, respectively. The

18   wireless environment 102 is used with CDMA-protocol mobile units and base

19   stations, and the wireless environment 103 is used with TDMA-protocol wireless

20   units and base stations.

21   Figure 2 shows the aircore platform 200 in more detail. In Figure 2, the

22   aircore platform 200 includes a mobile switching center (MSC) 210. The MSC 210 is

23   configured such that the aircore platform 200 can receive and transmit multiprotocol

24   wireless communications and wired communications with a variety of platforms. The

25   MSC 210 may include a visitor location register (VLR). Alternately, the VLR may

26   be separated from the MSC 210. The aircore platform 200 also includes a home

27   location register (HLR) 212. The HLR 212 includes permanent information about

28   customers who use the local environment serviced by the aircore platform 200. The

29   data stored in the HLR 212 is the permanent data that is independent of the customer's

1   present location, plus temporary data stored such as the address of the system (may be

2   signaling system 7 (SS-7) or other system) where the mobile unit is currently

3   registered and the address of service centers that have short messages for a mobile

4   unit. An example of such a short message is a request to turn on a voice message

5   waiting lamp indicating that a voice message has been stored for the mobile unit's use

6   in a voice messaging system. These addresses are erased after the short messages

7   have been delivered. The signaling system 7 (SS-7) is described in detail in A.R.

8   Modarressi, et al., "Signaling System No. 7: A Tutorial," *IEEE Communications*

9   *Magazine*, July 1990, pp. 19-35.

10   The VLR contains the profile data for the mobile unit and the transient data for

11   each mobile customer, including the mobile unit's present or most recently known

12   location area, the mobile unit's on/off status, and security parameters.

13   An authentication center 213 is used to ensure that only properly authorized

14   mobile and wired sources communicate through the aircore platform 200. The

15   authentication center 213 provides authentication encryption parameters to ensure that

16   a mobile customer cannot falsely assume the identity of another mobile customer and

17   provides data for encryption of the voice data, and control signals transmitted via the

18   air between the mobile unit and the servicing base station system. Encryption is

19   desirable for the transmission of messages between the mobile unit and the radio

20   transceiver at a base station serving that mobile unit because it is possible to listen in,

21   or tap, the radio channels carrying voice communications.

22   An equipment identity register (EIR) 211 includes a database of the mobile

23   equipment using the aircore platform 200, including specific protocols and equipment

24   preferences. The EIR 211 retains the ranges of certified equipment identifications and

25   the ranges of, or the individual equipment identifications that are under observation or

26   barred from service. The equipment identification information is received from a

27   mobile unit at the MSC 210. The EIR 211 is used to verify that the equipment

28   number of the mobile unit is certified for use in the public network and is not on the

29   observation or service barred list.

1   The MSC 210 is connected to other wireless network components and to the

2   PSTN for accessing land-based customer stations and to the integrated services digital

3   network (ISDN) for communicating according to ISDN protocols. A base station

4   system (BSS) 104 may include the BSC 105 and one or more BTSs 110 for

5   communicating with mobile units. The BSS 104 and the mobile units communicate

6   via radio connections. The BSS 104 is also connected via trunks to carry the voice,

7   data, and control messages between the mobile units and the MSC 210. The BSC 105

8   and the BTS 110 may be in different physical locations (for example, the BSC 105

9   may be co-located with the MSC 210 in which case a trunk is required to interconnect

10   the two). This is done since the communications between the BTS 110 and the BSC

11   105 can typically be compressed to optimize the BTS connectivity requirements.

12   Figures 3 - 7 show different mobility architectures that can be used with the

13   aircore platform 200. In Figure 3, the aircore platform 200 is shown communicating

14   with the BTS 110. The BTS 110 may service the wireless local loop 150. The aircore

15   platform 200 may also connect with the PSTN 120.

16   Figure 4 shows the aircore platform 200 used in conjunction with fixed

17   wireless local loop customers. In Figure 4, the fixed wireless local loops 151 include

18   a number of fixed customers in each of the local loops 151. The local loops 151

19   provide telephony services to fixed wireless customers in their respective loops. The

20   services are provided via a fixed terminal (not shown) that is attached to a location

21   and typically extends via a standard two-wire or similar connection to an analog

22   telephone within the location. Call processing and feature management are handled

23   by the aircore platform 200 as for a normal wireless customer. The only difference for

24   the aircore platform 200 is that the area of operation for the fixed terminal does not

25   change. Even though the terminal is using a wireless interface for communications,

26   the terminal's location remains fixed. The aircore platform 200 processes the calls to

27   and from the customer in the same manner as with mobile wireless calls because the

28   air interface determines the protocol and the feature set that is to be used to

29   communicate with the customer's fixed terminal. The protocol can be any of the

1   wireless protocols (CDMA, TDMA, AMPS, GSM). To limit the area of

2   communications for a particular fixed terminal, the aircore platform 200 can be

3   configured to only allow service to a particular location area for a particular fixed

4   terminal.

5   The aircore platform 200 provides a full range of mobile services to a wireless

6   local loop, or location area. In Figure 5, the aircore platform 200 is shown providing

7   mobile services to a wireless local loop 152 and a wireless local loop 153. In this type

8   of mobility situation, customers may move with their wireless terminals in a given

9   wireless local loop or location area. Movement outside of the location area is not

10   supported for these types of terminals. A typical implementation of this type of

11   mobility is provided in a village or town scenario where the coverage is disjointed

12   from other parts of the telecommunications system.

13   Figure 6 shows a system level mobility scenario that permits mobility for the

14   customer across all location areas under the control of the local aircore platform 200.

15   In Figure 6, the location area 154 and the location area 155 are both serviced by the

16   aircore platform 200. Moreover, customers in the location area 154 may freely move

17   through the location area 154 and the location area 155 and maintain wireless

18   communications with the aircore platform 200. This type of scenario can be found in

19   multiple towns or villages where a common aircore platform 200 is shared and the

20   coverage is contiguous or there is a considerable amount of allowable travel between

21   the locations covered by the system.

22   Figure 7 shows a full scale mobility scenario. In Figure 7, the aircore platform

23   200 communicates with a public land mobile network (PLMN) 158 and with local

24   wireless loops 156 and 157. The local wireless loops 156 and 157 also communicate

25   with the PLMN 158. This configuration provides for incoming and outgoing roaming

26   traffic to and from the local aircore platform 200 to other switching centers, which

27   may also be aircore platforms 200.

28   Figure 8 is a block diagram of a wireless network architecture according to the

29   invention. In Figure 8, the aircore platform 200 includes a MSC/VLR 210', a home

1   location register 224, an authentication center 226, and an equipment identification

2   register 225. The aircore platform 200 communicates with the base station system

3   (BSS) 104' using one or more protocols including GSM, CDMA, TDMA, and AMPS.

4   The aircore platform 200 also communicates with the PSTN 220 and other elements

5   of the wireless network. An alternate mobile telecommunications switch is also

6   shown in Figure 8. A MSC/VLR 210'' is coupled to the PSTN 220 and the BSS 104".

7   However, other modular components used in the mobile telecommunications

8   environment are located remotely from the MSC/VLR 210''. A system management

9   controller 230, a home location register 221, an equipment identification register 222

10   and an authentication center 223 may be physically separated from the MSC/VLR

11   210''. However, the functions of these modular components remain the same,

12   whether they are located with or remote from the MSC/VLR 210' and 210'',

13   respectively.

14   Figure 9 shows the functions and connections of the aircore platform 200. In

15   Figure 9, the visitor location register, the home location register, the equipment

16   identification register and the authentication center are shown co-located with the

17   MSC 210. The aircore platform 200 connects to the PSTN 120 via a T-1/E-1 line.

18   The aircore platform 200 is adapted to receive land-line originated telephone

19   messages. The aircore platform 200 can then send a connect message to an

20   appropriate base station system. The aircore platform 200 also allows intersystem

21   connection to an IS-41 wireless network 170 via a SS-7 link and a GSM wireless

22   network 160 via a SS-7 link. Optionally, these links may be based on other

23   communication carriage mechanisms such as IP, X.25, frame relay, or asynchronous

24   transfer mode (ATM).

25   The aircore platform 200 provides for intrasystem, or base station, wireless

26   communication using GSM protocols via a GSM BSC 240 and BTS 241. The aircore

27   platform 200 provides wireless communications using CDMA and TDMA via a IS-

28   634 link, an IS-95A BSC 244, a BTS 243 and a IS-136 BSC 242 and BTS 249. The

29   aircore platform 200 communicates with an AMPS BTS 246 using the ISDN PRI+ or

-13-

1 the IS-634 protocol. The aircore platform 200 provides communications with a

2 private branch exchange (PBX) 248 via T-1/E-1 lines. The aircore platform 200 also

3 provides for connection to a billing system 260 using TCP/IP protocols, for example,

4 and for voice mail and messaging functions via voicemail module 250.

5 **TABLE A**

TYPE	PROTOCOL	APPLICATION
Base Station	GSM "A" (Series 4 and 8)	GSM Network
	IS-651 & J-STD	US GSM based PCS
	IS-634 (IS-136)	DAMPS Network
	IS-634 (IS-95A)	CDMA Network
	IS-634 (AMPS)	Analog Network
	ISDN PRI+(AMPS)	Analog Network
Intersystem	GMS 09.02	GSM Network
	IS-652	US GSM based PCS
	ANSI-41	DAMPS, DCMA, AMPS Network
PSTN	T-1	T-1 Interface (various protocols) to the PSTN
	E-1	E-1 Interface (various protocols to the PSTN
Tandem	T-1	T-1 Interface tandem call traffic between local PBX and the PSTN
	E-1	E-1 Interface tandem call traffic between local PBX and the PSTN
Voice Mail	T-1	T-1 Interface to voice mail system
	E-1	E-1 Interface to voice mail system
Billing Center	TCP/IP	Interface for the transfer of Call Detail Records
NMC/OMC	TCP/IP	Interface for the exchange of Network Management related information

29 Table A shows a list of interfaces from the aircore platform 200 and the

30 functionality each of the interfaces adds. A Network Management Center/Operations

31 and Maintenance Center (NMC/OMC) 262 communicates with the aircore platform

1   200 using TCP/IP protocols, for example. The billing system 260 and the NMC/OMC

2   262 may also communicate with the aircore platform 200 using CCITT X.25

3   protocols.

4   Figure 10 is a block diagram of the aircore software architecture 300. In

5   Figure 10, the architecture 300 is shown including a system control module SCM

6   layer 310, a call processing control module handling the real time application layer

7   400, and a device handler layer 500. The SCM layer 310 maintains responsibility for

8   non-real time related applications, such as report management and configuration. The

9   SCM layer 310 generates and collects various types of report data, system

10   configuration information and system maintenance procedures. The SCM layer 310

11   may be logically and physically separated from the rest of the aircore software

12   architecture 300.

13   The call processing control module of the real time application layer 400

14   handles the application layer tasks that are real-time related. At the real time

15   application layer 400 of software, direct knowledge of specific protocols is not

16   required. Instead, this layer handles functions from a generic standpoint. For

17   example, a call processing state machine processes mobile originated call set up in the

18   same manner regardless of the type of interface used to connect to the base station

19   equipment. The event set and state machine commonality allow lower layers of

20   software to change without effecting the call processing control module of the real

21   time application layer 400.

22   The device handler layer 500 is the lowest layer of software in the aircore

23   software architecture 300. The device handler layer 500 contains the specific software

24   applications to receive and transmit protocol specific messages.

25   The SCM layer 310 includes a control panel (CTL) 312, which is the father

26   process of all the other processes in the system. The CTL 312 is responsible for

27   startup and auditing of the overall aircore software architecture 300. Once started, the

28   CTL 312 is only involved in limited auditing functions.

1   A call record management (SCR) 314 tracks the call report data generated in

2   the system. These records can be used for billing tracking, system tendencies, or

3   prepaid type of access. Call records are archived and the files rotated periodically.

4   For example, the files may be rotated hourly. Real-time output is accessible via

5   standard output options such as a printer or a screen output. Archived output is

6   accessible on screen, or may be accessed over a standard TCP/IP network or dial up.

7   An operational measurements manager (OMM) 316 is responsible for tracking

8   system counters. A count is defined as the occurrence of a particular situation. Each

9   time the situation occurs, the counter is incremented. Operational measurements are

10   archived and the files rotated periodically. For example, the files may be rotated

11   hourly. Each time a new file is created, each of the counters is reset to zero. This type

12   of data is captured to allow an operator to track system performance and tendencies

13   over time. Operational measurements are archived into files rotated periodically.

14   Real-time output is accessible using standard output options such as a printer or a

15   screen output. Archived output is accessible on-screen or can be accessed over a

16   standard TCP/IP network or dial up.

17   A real-time log report manager (RTL) 318 tracks system level reports. System

18   level reports are generated to notify an operator of certain tasks or situations occurring

19   on the aircore platform 200. For example, at the top of the hour, the system level

20   audit log reports may be output. Log reports range from reporting normal system

21   maintenance events to system status changes. Log reports are archived into files

22   rotated periodically. Real-time output is accessible using standard output options such

23   as a printer or a screen output. Archived output is accessible on screen or can be

24   accessed over a standard TCP/IP network or dial up.

25   An auto removal process (AUTO) 322 is responsible for automatic removal of

26   outdated archived report files. Automatic removal may occur on a periodic basis,

27   such as monthly.

28   A network management database administration (NMS) 324 allows access to

29   databases that provide configuration information for routing, rating and language for

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1   mobile devices. A system configuration (SYSCFG) 326 allows access to the

2   configuration of system telephony hardware resources. A system maintenance

3   (SYSMTC) 328 allows access to operator-initiated maintenance procedures.

4   A visitor location register interface VLI 332 provides the operator access to a

5   visitor location register. A home location register interface (HLI) 334 provides an

6   operator interface to the home location register and authentication center information.

7   An equipment identity register interface (EII) 336 provides an operator interface to the

8   equipment identity register. The VLI 332, HLI 334 and EII 336 may be implemented

9   as a graphical user interface(s) (GUI) or as batch type operations. These interfaces

10   will be described in more detail later.

11   The call processing control module (CPCM) of the real time application layer

12   400 includes a recovery and startup (REC) 402, which is the father process of the

13   software subsystems in the real time application layer 400 and at the device handler

14   layer 500. The REC 402 manages the maintenance states for the trunk and signaling

15   facilities in the real time application layer 400. The REC 402 interfaces with each of

16   the device handlers in the device handler layer 500 for maintenance and status as well

17   as with graphical user interface-based applications in the SCM layer 310 to process

18   operator initiated maintenance requests. The REC 402 also initiates an audit of all

19   real time application layer 400 subsystems. The audit may run every two minutes, for

20   example, and provides assurance that all subsystems are running properly.

21   A fault analysis unit (FAU) 404 is responsible for the collection of all log

22   reports and operational measurement related data created within the CPCM 400. The

23   FAU 404 to real-time layer interface is a singular path for this information to pass.

24   All CPCM 400 subsystems have access to pass events to the FAU 404 for this

25   purpose.

26   The timer manager (TIM) 406 provides timing facilities to call processing

27   control module subsystems in the aircore platform 200. The TIM 406 is used for

28   application level timers that operate on a one second or greater granularity. Timers

29   are stored in a list and are tracked until they are released or until they expire. Timers

1   requiring finer granularity or those that are specific to a particular subsystem's

2   requirements are controlled locally either in the subsystem or on board in the

3   hardware. The timers associated with the aircore platform 200 will be described later

4   in more detail.

5   A resource manager (RCM) 408 is used to manage base station resources

6   connected to the aircore platform 200. The RCM 408 has the capability to configure,

7   download, and track the state of individual cell site components as well as the base

8   station as a whole.

9   A CPCM call record management (CCR) 412 module provides for local

10   collection of call detail record (CDR) information for calls in progress. When calls

11   are completed, the CDR information is transferred from the CCR 412 to the SCR 314

12   in the SCM 310, where the call record data is processed and stored.

13   A call processing manager (CPM) 414 provides the processing required for all

14   communication channel establishment, tear down, feature processing and hand off

15   control. The state machines in place in the CPM 414 are based on a half-call model.

16   Each party in a session moves through a defined set of states based on received and

17   sent events, and timers used. Each side of a call steps through its own state. The two

18   sides of the call progress together. For a basic call setup, the state of one side of the

19   call is never more than one step ahead or behind the state of the other side. In the

20   CPM 414, each call placed requires the creation of a session object. This object is

21   created based on an index number created from the board span and channel used by

22   the originator of the call. The session adds and removes call objects as dictated by the

23   progress of the call. The reference number for the session is always based on the

24   originator's board span and channel. However, the session may also be indexed via

25   the index number of the board, span and channel of any of the involved parties.

26   A hand off processor (HOP) 416 is responsible for the preprocessing required

27   for hand off or hand over (GSM). Based on the technology and the involvement of

28   intersystem border cells, the level of involvement of the HOP 416 varies from one air

29   interface protocol to the next. However, like other modules performing specific

1   functions, the unique aspects of the protocol are handled internally in the HOP 416.

2   The interface to the CPM 414 for hand off processing is made generic. Preprocessing

3   in relation to handoff processing refers to the collection of data and the decision

4   process used to determine the appropriate base station to target for the hand off. This

5   entire process has been formed into a generic procedure within the aircore software

6   architecture 300.

7   A tone and announcement manager (TAM) 418 is responsible for management

8   of the digital signal processor resources in the system used for playing tones and

9   announcements. The TAM 418 interacts directly with the CPM 414 to provide the

10   necessary digital signal processor allocations. The digital signal processors are

11   controlled by components of the device handler 500. Direct communication to the

12   device handler from the CPM 414 is avoided so that the CPM 414 does not have to

13   maintain direct knowledge of the current digital signal processor configuration and

14   allocations.

15   A visitor location register (VLR) 422 is responsible for establishing and

16   maintaining a VLR database for the aircore platform 200. As shown in Figure 10, the

17   VLR 422 is co-located with the aircore platform 200. However, the VLR 422 could

18   be located remotely from the aircore platform 200. The VLR 422 is a collection of

19   customer profiles for users currently active on the system. The VLR 422 is a dynamic

20   database created and maintained while the aircore platform 200 is running. The VLR

21   422 communicates with threads inside an Advanced Intelligent Message Handler

22   (AIM) 430, which will be described later, for real-time application messaging. Any

23   communications to or from the VLR 422 from the CPCM 400 are received via the

24   AIM 430. Communications with the VLI 332 are limited to those necessary to allow

25   for the display of individual customer profile information, listing the current profiles

26   in the VLR 422 and allowing an operator the ability to update customer profiles from

27   the VLR database.

28   A home location register/authentication center (HLR) 424 is responsible for

29   establishing and maintaining the HLR database for the aircore platform 200. As

1   shown in Figure 10, the HLR 424 is co-located with the aircore platform 200.

2   However, the HLR 424 could also be located remotely from the aircore platform 200.

3   In addition, the functions of the HLR 424 could be carried out in separate HLR and

4   AC modules. The HLR 424 includes a collection of permanent customer profiles for

5   users homed on the system. The HLR 424 is a static database that tracks the current

6   location of a customer in addition to the individual profile parameters and status of

7   customer-related features. The HLR 424 communicates with the AIM 430 for real-

8   time application messaging. Any communications to or from the HLR 424 in the

9   CPCM 400 are received via the AIM 430. Communications with the HLI 334 are

10 limited to those necessary to allow for the manipulation of individual customer

11 profiles, listing the current customer profiles in the HLR 424, and allowing an

12 operator to update the customer profiles.

13   The HLR 424 also contains the functionality to perform the advanced security

14 calculations used in digital air interface protocols. These calculations are based on a

15 piece of secret data combined with a random number to yield a result that only has

16 meaning to the authentication center and the mobile unit. This functionality is

17 included in the HLR database and is integrated as part of the customer profile. The

18 actual comparison of data is done in the AIM 430 or in the HLR 424 itself, depending

19 on the protocol. Since the authentication center is integrated in the HLR 424,

20 communications with the authentication center all funnel through the HLR 424. The

21 authentication process will be explained in more detail later.

22   An equipment identity register (EIR) 426 is responsible for establishing and

23 maintaining an EIR database for the aircore platform 200. The EIR database is a

24 collection of the serial number information for mobile telephone handsets and other

25 equipment in the system. The EIR 426 normally maintains at least three lists:

26   White - range listing of valid international mobile equipment identities

27 (International Mobile Equipment Identity (IMEI)) (serial numbers).

28   Gray - list of individual serial numbers of questionable phones. Usage is

29 operator dependent.

1   Black - list of individual serial numbers of equipment prohibited from using

2   the system.

3   The EIR 426 is used with GSM-type systems. However, application to other

4   system protocols may also be accomplished. The EIR 426 communicates with the

5   AIM 430 for real-time application messaging. Any communications to or in the EIR

6   426 from the CPCM 400 are received via the AIM 430. Communications between the

7   EIR 426 and the EII 336 are limited to those necessary to allow for the manipulation

8   of list information. This includes allowing an operator to add, modify and delete from

9   the information the EIR database.

10   The device handler 500 includes a portion of the AIM 430. The device

11 handler 500 includes a device handler for digital CAS interface (DHD) 501, a device

12 handler for voice input and output devices (DHA) 502, a device handler for ISDN

13 interfaces (DHI) 503, a device handler for conference (DHC) 504, and a device

14 handler for timers (DHT) 505. The AIM 430 also includes a device handler for SS-7

15 (DH-7) 510.

16   Figure 11 is a logical diagram of the advanced intelligent message handler

17 (AIM) 430. The AIM 430 provides for advanced protocol processing, message

18 routing and system interfaces for the wireless network. The AIM 430 is built around

19 the steps required to establish call processing, mobility, and servicing in a wireless

20 environment. The basic approach of the AIM 430 is to use a multi-thread system to

21 isolate protocols and functions required for the mobility environment. Each different

22 protocol family supported by the aircore platform 200 is handled by a thread

23 specifically constructed for the message sent and state machine for that protocol.

24   Communications to various software entities such as the VLR, HLR, and EIR

25 funnel through the AIM 430 subsystem. This approach is taken to remove the

26 knowledge of the low layer message destination from each of those entities. This

27 approach also allows for the isolation of protocol specifics to the AIM 430 layer of

28 software. Finally, this approach allows for the seamless separation of these functions

29 to physically separate entities without effecting the application software. The

1   following is an example of the benefit of this approach: When the CPM 414 needs to

2   request the current location of a subscriber from the HLR 424, the message is sent to

3   the AIM 430 subsystem without the direct knowledge of the HLR location or the

4   protocol used to communicate with the HLR 424. The AIM 430 handles the routing

5   (either internal or external) and the selection and construction of the appropriate

6   message based on the protocol.

7   In Figure 11, a main AIM thread 438 is shown along with subordinate threads

8   431-436. In addition, a common memory 439 is used to share data related to a

9   transaction or connection between the subordinate threads 431-436 and the device

10 handler for SS-7 (DH-7) 510. Since each of the procedures followed for call

11 establishment, location updating, etc., involve multiple threads and actions, the

12 common memory 439 optimizes the performance of the AIM 430 by reducing the

13 copying of data between threads while at the same time allowing data sharing across

14 all of the threads by simply passing a pointer.

15   The A-interface message handler (AMH) 431 provides message decoding and

16 encoding for interface processing between an external base station and the aircore

17 platform 200 event structures and state machines.

18   Figure 12 is a block diagram of the logical architecture of the A-interface

19 message handler AMH 431. Communications received from a base station interface

20 are first interpreted by the AMH 431. The encoding and decoding specification for a

21 particular protocol are contained in dynamic linked libraries 441 and 442 that are

22 linked to the AMH 431. Each variant of the A-interface has its own unique set of

23 builder/decoder dynamic linked libraries. Each type of A-interface utilizes its own

24 instance of the AMH 431. Also shown in Figure 12 are timers 443_i through 443_n.

25 The timers 443_i-443_n, which control operations of state machine call processing for a

26 given connection, will be described in more detail later.

27   Figure 13 is a logical block diagram of the ISUP message handler (SMH) 436

28 logical architecture. The SMH 436 provides appropriate message conversion between

29 the application programming interface and the internal aircore subsystem event

1   structures. As shown in Figure 13, the SMH 436 is logically linked to the board levels

2   at boards 444_1-444_n.

3   Figure 14 is a logical block diagram of the intersystem message handler (IMH)

4   432 architecture. The IMH 432 encodes and decodes protocol messages related to a

5   mobile unit from an external communications system. These messages are called

6   Mobile Application Part. The encoding and decoding specifications for a particular

7   protocol are contained in the dynamic linked libraries 445 and 446 that are linked to

8   the IMH 432. Each variant of the MAP interface has its own unique set of

9   builder/decoder dynamic linked libraries. Each type of MAP interface utilizes its own

10   instance of the IMH thread 432. Also shown linked to the IMH thread are timers

11   447_1-447_n. The function of the timers 447 will be described in more detail later.

12   An authentication and registration processing (ARS) thread 434 (see Figure

13   11) provides appropriate calculations, comparisons and invocations of the required

14   authentication for a given base station interface. A paging processing (PAG) thread

15   435 (see Figure 11) provides the processing necessary for paging in the AirCore

16   system. Paging is the mechanism for locating and starting the process of notifying a

17   mobile unit of an incoming call or message.

18   Figure 15 is a logical block diagram of the device handler for voice I/O

19   devices (DHA) 502. The DHA 502 provides control of voice I/O resources in the

20   aircore platform 200 that are used for playing tones and announcements. The DHA

21   502 is a single process that spawns individual threads for each digital signal processor

22   that is accessible. As shown in Figure 15, the DHA 502 spawns digital signal

23   processor threads 522_1 through 522_n. The aircore platform 200 uses the first five

24   digital signal processors in the system to play standard tones. These tones are

25   accessible to all ports on the system. This approach satisfies the requirements of

26   playing ring-back or busy tones to all ports simultaneously. After the first five digital

27   signal processors, the remaining digital signal processors are allocated to a pool that

28   may be used in real-time call processing to play tones or announcements for call

29   progressing. The five digital signal processors are used for the standard tones of ring

1   back, busy, fast busy, dial tone and confirmation beep. To play announcements for

2   call progressing, the DHA 502 works with the tone and announcement manager

3   (TAM) 418 (not shown, see Figure 10), which receives its commands from the CPM

4   414.

5   Figure 16 shows the device handler for digital channel associated signaling

6   (CAS) interface (DHD) 501 in more detail. Channel associated signaling is a method

7   of signaling in telecommunications where a portion of each channel between two

8   entities is allocated for the carriage of the signaling and supervision in formations.

9   The DHD 501 is a multi-thread, multi-process subsystem that provides for CAS

10   processing.

11   Each channel in the DHD 501 is allocated a thread for processing the low layer

12   protocol state machine. As shown in Figure 16, spans 511_1-511_n are associated with

13   processing threads 512_1-$512_{24/32}$ and 513_1-$513_{24/32}$. The top layer process in the DHD

14   501 architecture is responsible for the interworking between the thread output in the

15   real time application layer 400.

16   Figure 17 shows the device handler for ISDN interfaces (DHI) 503. The DHI

17   503 is a multi-threaded, single process subsystem that provides processing for

18   common channel signaling interfaces. The DHI 503 is used internally in the aircore

19   platform 200 to handle facilities (T-1 or E-1) that use common channel signaling

20   methods. Common channel signaling provides a single signaling channel for the

21   control of signaling and supervision information for many channels of resources (e.g.,

22   a single channel is used to pass the appropriate signaling for all of the associated

23   traffic channels). Typically the signaling channel is based on an industry signaling

24   method such as SS-7, LAPD, or TCP/IP. In the DHI 503, a top layer process is

25   responsible for communications to the internal aircore platform 200 subsystems.

26   Linked to the DHI 503 are board level threads 520_1-520_n. The board level threads

27   520_1-520_n are used to handle individual boards in the aircore platform 200.

28   Figure 18 is a logical block diagram of a device handler for SS-7 (DH-7) 510.

29   The DH-7 510 exists for the purpose of handling the board level API for the SS-7

1   links in the system. The main tasks of the DH-7 510 are the basic assignment of

2   threads to the SS-7 links and assuring proper message routing for inbound messages to

3   the internal aircore subsystems and threads. Each SS-7 link established in the system

4   has its own link level thread that exists as a subordinate thread to the main DH-7 510

5   thread.

6   Figure 19 is a logical block diagram showing interlayer communications

7   among the SCM layer 310, the real time application layer 400 and the device handler

8   layer 500. In Figure 19, a two-way communications path 350 between the CTL 312

9   and the REC 402 is used to start the real time application layer 400 and report the

10   appropriate status information. One-way path 351 is used to transfer CDRs from the

11   real time application layer 400 to the SCM layer 310. One-way path 352 between the

12   FAU 404 and the RTL 318 is used to transfer report and operational measurement

13   pegs from the real time application layer 400 to the SCM layer 310. One-way path

14   353 between the SYSMTC 328 and the REC 402 is used to pass maintenance related

15   commands to the real time application layer 400 from the SCM layer 310. Two-way

16   path 354 from the VLI 332 to the VLR 422 is used to exchange information between

17   the VLR 422 and the VLR graphical user interface 332. Two-way path 355 between

18   the HLI 334 and the HLR 424 is used to exchange information between the HLR 424

19   and the HLR graphical user interface 334. Two-way path 356 between the EII 336

20   and the EIR 426 is used to exchange information between the EIR 426 and the EIR

21   graphical user interface 336.

22   Path 450 between the REC 402 and subsystem at the device handler layer 500

23   is defined for startup, status and maintenance communications used to interact with

24   the telephony board level hardware. The REC 402 communicates directly with all

25   device handler level subsystems with the exception of the DH-7 510, which is handled

26   via communications with the AIM 430. Two-way path 451 between the CPM 414 and

27   the device handler layer 500 is established for the exchange of messages for call

28   processing related activities in the aircore platform 200. The CPM 410 communicates

29   directly with all device handler 500 level subsystems with the exception of the DHA

1   502 and the DH-7 510. Communications path 452 between the TAM 418 and the

2   DHA 502 provides for the allocation and deallocation of voice I/O resources for tones

3   and announcements. Much like trunk groups that abstract the physical location of

4   trunks, this level of communication abstracts the physical location of the digital signal

5   processors used for playing the tones and announcements. Communications path 453

6   between the AMH 431, SMH 436, IMH 432 and the DH-7 510 provides for

7   communications between the SS-7 links and the builder/decoder threads in the AIM

8   430.

9   Figure 20 is a logical representation of the HLR 424. The HLR 424 contains

10   permanent data that is independent of the customer's present location, plus temporary

11   data such as the current location of the system where the mobile unit is registered and

12   the addresses of service centers that have stored short messages for mobile stations.

13   An example of such a message is a request to turn on a voice message waiting lamp

14   indicating that a voice message has been stored for the mobile station user in a voice

15   messaging system. These addresses are erased after the short messages have been

16   delivered.

17   As shown in Figure 20, the HLR 424 includes customer profiles 460_i for each

18   mobile customer. The customer profile 460_1 includes a customer data module 461.

19   The customer data module 461 includes a customer group identification, which is a

20   four digit number specifying the routing translations index for the customer. The

21   number must be previously configured in a routing translations data base via a routing

22   administration window. The customer data module 461 also includes the International

23   Mobile Customer Identity (IMSI), the International Mobile Equipment Identity (IMEI)

24   or Electronic Serial Number (ESN), which is the serial number of the handset

25   hardware, and the K_i, or A-key which is the key used for authentication calculations.

26   The customer data module 461 also includes the name of the customer, the language

27   for customer announcements, a three to five digit carrier ID identifier for long distance

28   carrier code associated with the customer, a check box for calling card features and a

29   prepaid feature. A call offering module 462 includes an indication of current features

1   such as call forwarding unconditional (CFU), call forward busy (CFB), call

2   forwarding no reply (CFNRy), and call forwarding not reachable (CFNRc), and call

3   forwarding default (CFD).

4   A VLR/MSC data module 463 indicates the VLR in and the MSC associated

5   with the current area of operation of the customer. A personal identification number

6   (PIN) data module 464 indicates if the customer uses a PIN when accessing the

7   system for calling card or long distance calls and the four digit PIN number associated

8   with the customer. A protocols module 465 is used for multi-mode customers to

9   determine the capabilities of the customers' units. The protocols may include, but are

10   not limited to, TDMA, CDMA, GSM and AMPS. A call restriction module 466

11   stores features for restricting the calling capabilities of the customer to and from the

12   network. The call restriction features include baring of all outgoing calls, suspended

13   service (no calls allowed), baring of all outgoing international calls, baring of all

14   incoming calls, baring of all outgoing international calls except those to the home

15   PLMN country and baring incoming calls to a customer when they are roaming to

16   another system.

17   A call features module 467 indicates the set of features allocated to a

18   customer. The call features include call hold, multi-party calling, 3-way calling,

19   roaming, call waiting and access to sending and receiving short messages. A line

20   identification module 468 identifies features that provide/restrict calling and called

21   number information to various parties in a call. The line identification features

22   include calling line ID presentation, calling number presentation, connected line ID

23   presentation, calling line ID restriction, calling number restriction, and connected ID

24   restriction.

25   A message center data module 469 provides for storage of short messages

26   pending delivery to a customer's mobile unit.

27   The HLR 424 may also include an authentication center. The authentication

28   center provides authentication and encryption parameters to insure that a mobile

29   customer cannot falsely assume the identity of another mobile customer. The

1   authentication center also provides data for encrypting the voice or data and control

2   signals transmitted via the air between the mobile station and the serving base station

3   subsystem. A GSM reference model prescribes digital communications over the radio

4   channels. Since it is possible to surreptitiously listen to these channels, encryption

5   becomes desirable for the link between the mobile station and the radio receiver at a

6   base station serving that mobile station. Any public or proprietary encryption

7   algorithm known in the art can be used with the aircore platform 200.

8   The calculations for the authentication center use the secret key information

9   associated with the subscriber and the protocol specific calculations. The HLR 424

10   pre-processes these authentication calculations and stores them as part of the

11   subscriber profile. As required, this information is shared with the servicing

12   MSC/VLR to authenticate the mobile unit as it accesses the system.

13   The VLR 422 contains current data for each active mobile customer, including

14   that customer's mobile station present or most recently known location area, the

15   mobile unit's on/off status, and security parameters. The VLR 422 is logically

16   constructed in the same manner as the HLR 424.

17   The HLR and VLR databases both simultaneously accommodate customer

18   profiles from any interface protocol. There are two significant classifications of

19   profile types, based on the intersystem protocol used to transmit and receive profile

20   information over the wireless network. Both GSM and IS-41 based networks share

21   common information in the customer profile structures, but each profile type also

22   requires fields and information that are unique to that particular protocol type. The

23   HLR and VLR databases provide for this by an internal structure that uses a common

24   top level header for the common data and then protocol specific attachments. This

25   internal structure is shown in Figure 21. A GSM side 417 and an IS-41 side 419 are

26   used with the VLR and HLR databases. A common data header 427 is used for both

27   GSM and IS-41 profile information. A GSM specific data area 428 is used for GSM

28   specific data. An IS-41 specific data area 429 is used for IS-41 specific data. The

29   common data header 427 allows the two sides of the database to use common search

1   routines while the specific data areas allows for the storage of data that pertains to a

2   specific protocol alone.

3   A description of the timers used by the MSC 210 will now be provided. A call

4   proceeds from initiation to connection through a series of steps. The time associated

5   with this call set up and connection is usually short. Nonetheless, one or more voice

6   channels may be reserved at the start of the call set up. If the call will not connect,

7   some mechanism is desirable to release these resources as quickly as possible so that

8   they may be used by other customers. Furthermore, during the time that the mobile

9   unit is held waiting for an incoming call, the mobile unit cannot call out or receive

10   other incoming calls. To free up resources and to release the mobile unit, the TMR

11   437, in conjunction with the TIM 406 (see Figure 10) includes a number of timers that

12   may be established at various points in the call set up and connect process. The timers

13   are generally set based on a message from the AMH 431 or similar interface.

14   A timer may be set when a device handler such as the device handler 510

15   requests a BSC 105 to assign a channel. In this case, the AMH 431 sends a message

16   to the TMR 437 to set the timer. If an assignment is not completed within the time

17   limit of the timer, the call connection process ends. If the assignment is completed

18   before expiration of the timer, the AMH 431 sends a message to the TMR 437 to

19   release the timer.

20   A timer may be associated with a connect message sent to the BSC 105 by a

21   device handler. If a connect acknowledgment message is received by the device

22   handler, the AMH 431 will send a timer release message, allowing the call connection

23   to complete. Similarly, a timer may be set to time out a make call command, a paging

24   message for a mobile terminated call, a disconnect message (GSM) or release message

25   IS-634) for PSTN and mobile originated calls, and a clear command to release a

26   channel during a call disconnect sequence. Other timers may be used to ensure

27   resources are returned for assignment to other calls.

28   Managing the location of a customer ensures the proper connection of the

29   customer's mobile unit for both mobile initiated calls and mobile terminated calls. In

1 Figure 22, the authentication and registration (ARS) 434 thread is shown in

2 communication with the common memory 439. The common memory 439 includes

3 the data relevant to the mobile unit and the state machine relevant to the protocol and

4 the transaction being performed. The ARS 434 maintains communications with the

5 AMH 431 and the IMH 432 to track ongoing transactions, to compare SRES, to send

6 TMSI to the mobile unit and to provide ciphering information to the AMH 431. The

7 IMH 432 provides connections to the VLR 422 and HLR 424 for obtaining customer

8 profile information.

9   The call processing module (CPM) 414 processes calls according to one of

10 several state machines. A state machine exists for each half of every call processed

11 through the aircore platform 200. A separate state machine exists for mobile

12 originated call processing, PSTN originated call processing and mobile terminated call

13 processing, for example. Figures 23-25 are examples of state machines used in

14 processing calls at the aircore platform 200. Figure 23 is a state machine 600 for

15 mobile originated call processing. In Figure 23, eight states are possible: idle (S1),

16 wait for UUI (S2), wait for page response (S3), wait for alert (S4), wait for connect

17 (S5), voice (S6), wait for handoff confirm (S7), tone and announce (S8), and wait for

18 call cleared (S9). The state machine 600 shows the allowed transitions between

19 states. Starting in idle S1, the state machine 600 can transition to state wait for UUI

20 S2 or wait for call cleared S9. The state machine 600 transitions to wait for UUI S2

21 based on reception of the mobile customer's profile when a CALL_RECEIVED

22 message is received. The state machine 600 transitions from idle S1 to wait for call

23 cleared S9 based on the mobile customer profile indicating a particular call restriction

24 or if the call fails before routing. With the authentication previously set up with the

25 A-interface protocol, this transition may not be possible.

26   In the wait for UUI state S2, the state machine 600 can transition to the wait

27 for alert state S4. This transition is based on receiving the ROUTE_CALL message.

28 The aircore platform 200 proceeds with making the call out to the called party if the

29 call type is direct dial (DD) in the routing translations or when a call delivery to a

1   mobile unit or another system is required. The CPM 414 then sends a MAKE_CALL

2   message. Next, the state machine 600 can transition from the wait for UUI state S2 to

3   the wait for page response S3 based on receiving a ROUTE_CALL message. A

4   PAGE_MOBILE message is sent to the PAG 435. The transition to this state is based

5   on a call type of MOB in the routing translations and finding that the called mobile

6   unit is operating in the aircore system. The state machine 600 transitions from the

7   wait for UUI state S2 to the tone and announce state S8 if the dialed number received

8   from the originating mobile unit fails to translate properly or if there is a restriction on

9   the called mobile unit. The originating mobile unit is then connected to a tone. This

10   transition could also occur by the CPM 414 receiving a PAGE_RESPONSE message

11   with a time out indication. Finally, the wait for UUI state S2 can transition to the wait

12   for call cleared state S9 based on receiving a disconnect from the mobile unit. When

13   the message CALL_DISCONNECTED is received at the CPM 414, a CLEAR_CALL

14   message is sent.

15   The state machine 600 transitions from the wait for page response S3 to the

16   wait for alert state S4 based on receiving a PAGE_RESPONSE message. A

17   MAKE_CALL message is then sent and the CPM 414 proceeds with an ISDN state

18   machine 600. The wait for page response state S3 transitions to the tone and

19   announce state S8 along transition path T8 based on receiving a time out for a page

20   response. The CPM 414 then provides a time out announcement or tone to the calling

21   party. The state machine 600 transitions from the wait for page response state S3 to

22   the wait for call cleared state S9 along transition path T9 based on receiving a

23   disconnect from the originating mobile unit. A CALL_DISCONNECTED message is

24   received at the CPM 414 and a CLEAR_CALL message is sent. The PAG thread 435

25   will time out and clear the page request data for the call.

26   The state machine 600 transitions from the wait for alert state S4 to the wait

27   for connect state S5 along transition path T10 based on receiving an alerting

28   indication from the called party. The alerting indication is passed to the mobile

29   customer's side of the call. The CPM 414 receives the CALL_ALERTING message

1   from the called party and sends an ALERT_CALL to the originating mobile unit. The

2   transition from the wait for alert state S4 to the voice state S6 occurs along transition

3   path T11 based on receiving a connect indication from the called party. The protocol

4   allows a CONNECT message to be received without receiving alerting. The CPM

5   414 receives a CALL_CONNECTED message from the called party and sends a

6   CONNECT_CALL message to the originating mobile unit. The transition from the

7   wait for alert state S4 to the tone and announce state S8 is along transition path T12.

8   This transition occurs for two possible reasons. First, the transition may be based on a

9   time out waiting for the alerting indication. The called party is cleared from the call

10   and the mobile customer is connected to an announcement or tone. The CPM 414

11   sends a CLEAR_CALL message to the called party. Second, the transition may be

12   based on receiving a disconnect from the called party with "user busy." The

13   originating mobile unit is sent an announcement and the called party is released from

14   the call. The CPM 414 receives a CALL_DISCONNECTED message from the called

15   party and sends a CLEAR_CALL message to the called party. Finally, the transition

16   from the wait for alert state S4 to the wait for call cleared state S9 occurs along

17   transition path T13 if the originating mobile customer disconnects from the call before

18   the CPM 414 receives the alerting indication from the called party. Clearing both

19   parties is initiated. The CALL_DISCONNECTED message is received from the

20   originating mobile unit. The CPM 414 sends a CLEAR_CALL message to both

21   parties.

22   The state machine 600 may transition from the wait for connect state S5 to the

23   voice state S6 along transition path T14 based on receiving connect indication from

24   the called party. The connect indication is passed to the mobile customer. The CPM

25   414 received a CALL_CONNECTED message from the called party and sends a

26   CONNECT_CALL message to the originating mobile unit. Transition from the wait

27   for connect state S5 to the tone and announce state S8 occurs when a time out occurs

28   waiting for the connect. The called party is cleared from the call and the mobile

29   customer is connected to a tone or announcement. The CPM 414 sends a

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1 CLEAR_CALL message to the called party. Transition from the wait for connect

2 state S5 to the wait for call cleared state S9 occurs along transition path T16 if the

3 originating mobile subscriber disconnects from the call before the CPM 414 receives

4 the connect indication from the called party. Clearing both parties is initiated. The

5 CPM 414 receives a CALL_DISCONNECT message from the originating mobile unit

6 and sends a CLEAR_CALL message to both parties.

7 The state machine 600 transitions from the voice state S6 to the wait for called

8 clear state S9 along transition path T17 based on receiving a disconnect indication

9 from either party. Call clearing is initiated for both parties on the call. A

10 CALL_DISCONNECTED message is received from one of the parties. The CPM

11 414 sends a CLEAR_CALL message to both parties. Transition from the voice state

12 S6 to the wait for hand off confirm state S7 occurs along transition path T18 based on

13 receiving a hand off request from the HOP 416 subsystem and having a B-channel to

14 allocate to the target BTS for the hand off. The CPM 414 receives a HAND_OFF

15 request from the HOP 416 and sends a MAKE_CALL message with a hand off

16 indicating to establish the target channel. Finally, the voice state S6 transitions back

17 to the voice state S6 along transition path T19 based on receiving a hand off request

18 and not having a B-channel available to the BTS.

19 The state machine 600 transitions from the wait for hand off confirm state S7

20 to the voice state S6 along transition path T20 based on three possible events. First,

21 the CPM 414 receives a hand off confirmation from the serving BTS. This indicates

22 the mobile unit has confirmed the hand off and is in transition to the target BTS. The

23 voice connection is switched to the target BTS at this point. The CPM 414 receives a

24 HAND_OFF_CONFIRM message and sends a CLEAR_CALL to the old serving

25 channel. The voice path in connected to silence until the CALL_CONNECTED

26 message is received on the target channel. Second, the CPM 414 receives a hand off

27 confirmation with a negative indication (failed). This indicates that the mobile unit is

28 not going to the target channel. The CPM 414 starts a disconnect sequence to release

29 the target channel. The CPM 414 then sends a CLEAR_CALL message to the target

1   channel. Third, the CPM 414 receives a failure on the channel setup with the target

2   BTS. The transition to the voice state S6 occurs and the CPM 414 initiates or

3   continues with the disconnect sequence with the target BTS channel. The CPM 414

4   sends a CLEAR_CALL message to the target channel. Transition from the wait for

5   confirm state S7 to the wait for call cleared state S9 occurs along transition path T21

6   based on receiving a disconnect from either party while a target BTS channel is being

7   established for the hand off. The CPM 414 initiates clearing all resources and

8   transition. The CPM 414 receives a CALL_DISCONNECTED message and sends a

9   CLEAR CALL message to the parties.

10   The state machine 600 transitions from the tone and announce state S8 to the

11   wait for call clear state S9 along transition path T22 based on the originating mobile

12   unit disconnect indication being received from the CPM 414. This can occur as a

13   result of a time out after the tone or an announcement is played and a disconnect is not

14   received. In this case, the CPM 414 initiates the disconnect with the mobile customer.

15   The CPM 414 initiates the disconnect with the mobile customer. The CPM 414 either

16   receives a CALL_DISCONNECTED message and sends a CLEAR_CALL message

17   or the CPM 414 receives a time out and sends a CLEAR_CALL message.

18   The state machine 600 transitions from the wait for call cleared state S9 to the

19   idle state S1 along transition path T23 based on both parties confirming they are

20   cleared from the call. In cases where there is no other party involved in the call, the

21   confirmation of the clearing of the party is implied by the fact that the cell never

22   existed. This transition takes place when the call is completely cleared. The CPM

23   414 receives a CALL_CLEARED message from the originating mobile unit.

24   Figure 24 is a state machine 601 for PSTN originated call processing. In the

25   state machine 601, the wait for UUI state S2 and the wait for handoff confirm state S7

26   are not allowed states. The state machine 601 transitions from the idle state S1 to the

27   wait for page response state S3 along transition path T24 based on determining the

28   need to page the mobile customer. The CPM 414 sends a PAGE_MOBILE message

29   to the PAG thread 435. Transition from the idle state S1 to the wait for alert state S4

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1   occurs along transition path T25 based on determining that the mobile customer is

2   located on another system and the aircore platform 200 has received a routing number

3   to call the current serving switch. The CPM 414 sends a MAKE_CALL message

4   using the TLDN (MSRN GSM). The transition from the idle state 51 to the wait for

5   alert state 54 can also occur under a forwarding condition of the original destination

6   number. Transition from the idle state S1 to the tone and announce state S8 occurs

7   along transition path T26 if the called number received from the originating PSTN

8   party fails to translate properly or if there is a restriction on the called mobile unit. In

9   this case the originating PSTN party is connected to a tone or announcement. This

10   transition could also occur by the CPM 414 receiving a PAGE_RESPONSE message

11   with a time out indication.

12   The state machine 601 transitions from the wait for page response state S3 to

13   the wait for alert state S4 along transition path T27 based on receiving a

14   PAGE_RESPONSE message. The CPM 414 sends a MAKE_CALL message and

15   proceeds with the ISDN state machine. Transition from the page response state S3 to

16   the tone and announce state S8 occurs along transition path T28 based on receiving a

17   time out for a page response (i.e., PAGE_RESPONSE message received by the CPM

18   414 with a time out indication). The CPM 414 provides a time out announcement or

19   tone to the calling party. Transition from the wait for page response state S3 to the

20   wait for call cleared state S9 occurs along transition path T29 based on receiving a

21   disconnect from the originating PSTN party. The CPM 414 receives a

22   CALL_DISCONNECTED message and sends a CLEAR_CALL message. The PAG

23   thread 435 will time out and clear the page request data for the call.

24   The state machine 601 transitions from the wait for alert state S4 to the wait

25   for connect state S5 along transition path T30 based on receiving an alerting

26   indication from the called party. The alerting indication is passed to the PSTN side of

27   the call. The CPM 414 received a CALL_ALERTING message from the called party

28   and sends an ALERT_CALL message to the originating PSTN party. Transition from

29   the wait for alert state S4 to the voice state S6 occurs along transition path T31 based

1   on receiving a connect indication from the called party. The protocol allows reception

2   of the connection without receiving alerting. The CPM 414 receives a

3   CALL_CONNECTED message from the called party and sends a CONNECT_CALL

4   to the originating PSTN party. Transition from the wait for alert state S4 to the tone

5   and announce state S8 occurs along transition path T32 for two possible reasons.

6   First, transition may be based on a time out waiting for the alerting indication. The

7   called party is cleared from the call and the PSTN party is connected to an

8   announcement or tone. The CPM 414 sends a CLEAR_CALL message to the called

9   party. Second, transition may be based on receiving a disconnect from the called party

10 with "user busy." The originating PSTN party is sent an announcement and the called

11 party is released from the call. The CPM 414 receives a CALL_DISCONNECTED

12 message from the called party and sends a CLEAR CALL message to the called party.

13 Transition from the wait for alert state S4 to the wait for call cleared state S9 occurs

14 transition path T33 if the originating PSTN party disconnects from the call before the

15 CPM 414 receives the alerting indication from the called party. Clearing of both

16 parties is initiated. The CPM 414 receives a CALL_DISCONNECTED message from

17 the originating PSTN party and sends a CLEAR_CALL message to both parties.

18   The state machine 601 transitions from the wait for connect state S5 to the

19 voice state S6 along transition path T34 based on receiving connect indication from

20 the called party. The connect indication is passed to the PSTN party. The CPM 414

21 receives the call connected message from the called party and sends the

22 CONNECT_CALL message to the originating PSTN party. Transition from the wait

23 for connect state S5 to the tone and announce state S8 occurs along transition path

24 T35 when a time out occurs waiting for the connect. The called party is cleared from

25 the call and the PSTN party is connected to a tone or announcement. The CPM 414

26 sends a CLEAR_CALL message to the called party. Finally, transition from the wait

27 for connect state S5 to the wait for call cleared state S9 occurs along transition path

28 T36 if the originating PSTN party disconnects from the call before the CPM 414

29 receives the connect indication from the called party. Clearing both parties is

1   initiated. The CPM 414 receives a CALL_DISCONNECTED message from the

2   originating PSTN party and sends the CLEAR_CALL message to both parties.

3   The state machine 601 transitions from the voice state S6 to the wait for call

4   cleared state S9 along transition path T37 based on receiving a disconnect indication

5   from either party. Call clearing is initiated for both parties. The CPM 414 receives

6   the CALL_DISCONNECTED message from one of the parties. The CPM 414 then

7   sends the CLEAR_CALL message to both parties.

8   The state machines 601 transitions from the tone and announce state S8 to the

9   wait for call cleared state S9 along transition path T38 based on the originating mobile

10   unit disconnect indication being received from the CPM 414. This can also occur as a

11   result of a time out after the tone or announcement is played and a disconnect is not

12   received. In this case, the CPM 414 initiates the disconnect with the mobile customer.

13   The CPM 414 either receives a CALL_DISCONNECTED message and sends a

14   CLEAR_CALL message or the CPM 414 receives a time out and sends the

15   CLEAR_CALL message.

16   The state machine 601 transitions from the wait for call cleared state S9 to the

17   idle state S1 along transition path T39 based on both parties confirming they are

18   cleared from the call. In cases where there is no other party involved in the call the

19   confirmation of the clearing of the party is implied by the fact that it never existed.

20   Transition takes place when the call is completely cleared. The CPM 414 receives the

21   CALL_CLEARED message from the originating mobile unit.

22   Figure 25 shows a state machine 602 for a mobile terminated call processing.

23   As shown in Figure 25, the states wait for UUI S2, wait for page response S3 and tone

24   and announce S8 are not used in a mobile terminated call processing scenario. The

25   state machine 602 transitions from the idle state S1 to the wait for alert state S4 along

26   transition path T40 based on reception of a valid PAGE_RESPONSE message. The

27   CPM 414 sends a MAKE_CALL message to the terminating mobile unit. The idle

28   state S1 returns to the idle state S1 along transition path T41 based on a page time out,

1   or failure in routing. The calling party is sent to an announcement or the call is

2   forwarded based on the customer's feature profile.

3   State machine 602 transitions from the wait for alert state S4 to the wait for

4   connect state S5 along transition path T42 based on receiving an alerting indication

5   from the terminating mobile customer. The alerting indication is passed to the calling

6   party's side of the call. The CPM 414 receives a CALL_ALERTING message and

7   sends a ALERT_CALL message to the calling party. Transition from the wait for alert

8   state S4 to the voice state S6 occurs along transition path T43 based on receiving a

9   connect indication from the called mobile unit. The protocol allows receipt of a

10 receive connect message without receiving alerting. The CPM 414 receives a CALL_

11 CONNECTED message from the called party and sends a CONNECT_CALL

12 message to the calling party. Transition from the wait for alert state S4 to the wait for

13 call cleared state S9 occurs along transition path T44 if the calling party disconnects

14 from the call before the CPM 414 receives the alerting indication from the mobile

15 customer. Clearing both parties is initiated. The CPM 414 receives a CALL

16 DISCONNECTED message from the calling party and sends a CLEAR_CALL

17 message to both parties. In addition, in time out cases where the calling party is sent

18 to an announcement, the called mobile unit will receive a CLEAR_CALL message

19 from the CPM 414 and make the transition.

20 The state machine 602 transitions from the wait for connect state S5 to the

21 voice state S6 along transition path T45 based on receiving a connect indication from

22 the called mobile customer. The connect indication is passed to the calling party. The

23 CPM 414 receives a CALL_CONNECTED message and sends a CONNECT_CALL

24 message to the calling party. Transition from the wait for connect state S5 to the wait

25 for call clear state S9 occurs along transition path T46 that the calling party

26 disconnects from the call before the CPM 414 receives the connect indication from

27 the mobile customer. Clearing both parties is initiated. The CPM 414 receives a

28 CALL_DISCONNECTED message from the calling party. The CPM 414 then sends a

29 CLEAR_CALL message to both parties. In addition, in time out cases where the

1   calling party is sent to an announcement, the called mobile unit will receive a

2   CLEAR_CALL message from the CPM 414 and make the transition.

3   The state machine 602 transitions from the voice state S6 to the wait for call

4   cleared state S9 along transition path T47 based on receiving a disconnect indication

5   from either party. Call clearing is initiated for both parties in the call. The CPM 414

6   receives a CALL_DISCONNECTED message from one of the parties and sends a

7   CLEAR_CALL message to both parties. Transition from the voice state S6 to the wait

8   for hand off confirm state S7 occurs along transition path T48 based on receiving a

9   hand off request from the HOP subsystem 416 and having a B-channel to allocate to

10   the target BTS for the hand off. The CPM 414 receives a hand off request message

11   from the HOP 416 and sends a MAKE_CALL message with a hand off indication to

12   establish the target channel. Transition from the voice state S6 back to the voice state

13   S6 occurs along transition path T49 based on receiving a hand off request and not

14   having a B-channel available to the BTS.

15   The state machine 602 transitions from the wait for hand off confirm state S7

16   to the voice state S6 along transition path T50 in one of three situations. First, the

17   CPM 414 receives a hand off confirmation from the serving BTS. This indicates the

18   mobile unit has confirmed the hand off and is transitioning to the target BTS. Voice

19   connection is switched to the target BTS at this point. The CPM 414 receives the

20   HANDOFF_CONFIRM message and sends the CLEAR_CALL message to the old

21   serving channel. The voice path is connected to silence until the CALL_

22   CONNECTED message is received on the target channel. Second, the CPM 414

23   receives a hand off confirmation with a negative indication (failed). This indicates

24   that the mobile unit is not going to the target channel. A disconnect sequence to

25   release the target channel is started and the CPM 414 sends a CLEAR_CALL message

26   to the target channel. Third, the CPM 414 receives a failure of the channel set up with

27   the target BTS. Transition to the voice state S6 in initiation or continuation of the

28   disconnect sequence with the target BTS channel begins. The CPM 414 sends a

29   CLEAR_CALL message to the target channel. Transition from the hand off confirm

1   state S7 to the wait for call cleared state S9 occurs along transition path T51 based on

2   receiving a disconnect from either party while a target BTS channel is being

3   established for the hand off. The CPM 414 initiates clearing all resources and

4   transition. The CPM 414 receives a CALL_DISCONNECTED message and sends a

5   CLEAR_CALL message to all parties.

6   The state machine 602 transitions from the wait for call cleared state S9 to the

7   idle state S1 along transition path T52 based on both parties confirming they are

8   cleared from the call. In cases where there is no other party involved in the call, the

9   confirmation of the clearing of this party is implied by the fact that a call never

10   existed. This transition takes place when the call is completely cleared. The CPM

11   414 receives a CALL_CLEARED message from the originating mobile unit.

12   The aircore platform 200 uses a common facility state machine for tracking the

13   states and conditions of external connections or trunks. Two portions of the state are

14   tracked. Each facility has a near end and a far end state. The near end state represents

15   the internal aircore state for the facility. The far end state represents the state of the

16   facility as reported by the connected system. This state machine tracking applies to all

17   aircore interfaces including traffic channels and signaling channels. Like call

18   processing, these maintenance procedures are generic in the aircore platform 200

19   regardless of the interface.

20   Figure 26 is a aircore near end facility maintenance state machine 604. The

21   state machine 604 includes the states not configured (S10), blocked (S11), unblocked

22   pending (S12), unblocked (S13), call processing (S14), blocked pending (S15), and

23   maintenance (S16).

24   Figure 26 also shows the transitions between the states of the state machine

25   604. The state machine 604 transitions from the state not configured S10 to the

26   blocked state S11 along transition path T60 when a facility is added to the

27   configuration and is enabled.

28   The state machine 604 transitions from the blocked state S11 to the unblocked

29   pending state S12 over transition path T61 when either operator initiated or automatic

1 recovery occurs which requests that the destination device handler bring the requested

2 facility to an unblocked (in service) state. Transition from the blocked state S11 to the

3 maintenance state S16 occurs along transition T62 when the facility is taken to a

4 maintenance state to perform a maintenance or test operation. This transition is based

5 on an operator action. Transition from the blocked state S11 to the not configured

6 state S10 occurs along transition path T63 when the facility is disabled and/or

7 removed from the system configuration.

8 The state machine 604 transitions from the unblocked pending state S12 to the

9 unblocked state S13 over transition path T64 when a maintenance action is confirmed

10 by the device handler. The facility is now in service. Transition from the unblocked

11 pending state S12 to the blocked pending state S15 occurs over transition path T65

12 when a maintenance action is denied by the device handler or aborted by an operator

13 action.

14 The state machine 604 transitions from the unblocked state S13 to the call

15 processing state S14 along transition path T66 when the facility is allocated and will

16 be used for call processing. Transition from the unblocked state S13 to the blocked

17 pending state S15 occurs along transition path T67 when either operator initiated or

18 automatic maintenance action from the device handler. Transition also occurs based

19 on other internal action requests that the destination device handler bring the

20 requested facility to a blocked (off-line) state.

21 The state machine 604 transitions from the call processing state S14 to the

22 unblocked state S13 over transition path T66 when the facility is released from being

23 used in call processing. Transition from the call processing state S14 to the blocked

24 pending state S15 occurs over transition path T69 when a maintenance action is either

25 operator initiated or automatic from the device handler or other internal action

26 requests that the device destination handler bring the requested facility to a blocked

27 (off-line) state.

28 The state machine 604 transitions from the blocked pending state S15 to the

29 blocked state S11 over transition path T70 when a maintenance action to take facility

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1 off-line is confirmed by the device handler. In a case where the device handler does

2 not respond, the state may be reached by default of no response.

3 The state machine 604 transitions from the maintenance state S16 to the

4 blocked state S11 over transition path T71 when the maintenance action on the facility

5 is completed. Operator action is required to transition the state back to the blocked

6 state S11.

7 In addition to monitoring the near end state of the system facilities, the aircore

8 platform 200 also maintains the far end state of facilities where applicable. The far

9 end state represents the status of a facility at the connected system side. The far end

10 state and near end state are used together to determine the overall operational state.

11 Figure 27 shows the aircore far end facility maintenance state machine 605. In

12 Figure 27, the states are not configured (S17), blocked (S18), unblocked (S19), and

13 unknown (S20).

14 The state machine 605 transitions from the not configured state S17 to the

15 blocked state S18 along transition path T80 when a facility is added to the

16 configuration and enabled.

17 The state machine 605 transitions from the blocked state S18 to the unblocked

18 state S19 over transition path T81 when an unblocking request is received from the far

19 end. Confirmation is then sent back with an unblocking acknowledgment message.

20 Transition from the blocked state S18 to the unknown state S20 occurs over transition

21 path T82 when a discrepancy has been detected between the state reported by the far

22 end and the stored far end state for the facility in aircore platform 200. The blocked

23 state S18 transitions to the not configured state S17 over transition path T83 when the

24 facility is disabled and/or removed from the system configuration.

25 The state machine 605 transitions from the unblocked state S19 to the blocked

26 state S18 over transition path T84 when a blocking request message is received from

27 the far end. Confirmation is sent back with the blocking acknowledgment message.

28 Transition from the unblocked state S19 to the unknown state S20 occurs over

1   transition path T85 when a discrepancy has been detected between the state reported

2   by the far end and the stored far end state for the facility in the aircore platform 200.

3   The state machine 605 transitions from the unknown state S20 to the blocked

4   state S18 over transition path T86 when the far end reports the state of the facility is

5   blocked. Transition from the unknown state S20 to the unblocked state S19 occurs

6   over transition path T87 when the far end reports the state of the facility is unblocked.

7   Hand off processing occurs when an active mobile unit transitions from a

8   wireless region supported by one base station to a wireless region supported by a

9   second base station. Hand off processing may also occur as a mobile unit transitions

10 from one cell site within a wireless region to another sell site.

11   Figure 28 shows an aircore wireless environment 106 in which the aircore

12 platform 200 functions as a mobile switching center (MSC). There are many different

13 protocol scenarios that are possible for hand off processing in the aircore environment

14 106, including ISDN PRI+ with an AMPS base station, DHD-based (AMPS) base

15 station, IS-634 AMPS, IS-634 TDMA, IS-634 CDMA, GSM, IS-41 Revision B, IS-41

16 Revision C and GSM mobile application part (MAP). In addition, the processing

17 design of the aircore platform 200 retains the flexibility to easily adapt to other hand

18 off protocols. Finally, the aircore platform 200 may receive hand off requests from

19 multi-protocol mobile units.

20   In Figure 28, base station controllers (BSCs) 105_1, and 105_2 and base

21 transceiver stations (BTSs), are shown connected to the aircore platform 200 via

22 signal lines 485 and 495, respectively. The BSC 105_1 has an associated wireless

23 region 480 that includes BTSs 481, 482 and 483. The BSC 105_2 has an associated

24 wireless region 490 with BTSs 491, 492 and 493. The mobile unit 112 is active in the

25 wireless region 480 at point A and communicates with a land-line phone 114 via

26 PSTN 120, the aircore platform 200, the BSC 105_1 and the BTS 481.

27   In the above description, the BTS receives a call from a mobile unit. The

28 mobile unit may be a mobile telephone or a computer with a wireless modem, for

1   example. In addition, the BSC/BTS may be replaced in some scenarios with a BSS or

2   any other base station configuration.

3   During the course of a call, the mobile unit 112 transitions from point A in

4   wireless region 480 to point B in wireless region 490. As a result of this transition,

5   the BTS 105_1 detects that the signal level of the cell has dropped below the minimum

6   to continue the call on the current channel. The BSC 105_1 notifies the aircore

7   platform 200, which begins hand off processing to establish a new cell site using the

8   BSC 105_2. When the new cell site is established, the aircore platform 200 tears down

9   the previous link, thereby freeing up resources for other wireless customers.

10   In the scenario described above, the BSC 105_1 and 105_2 are both associated

11   with the aircore platform 200 and certain hand off processing functions such as

12   strength measurements are performed by the aircore platform 200. In a scenario

13   involving a base transceiver station coupled to another mobile switching center, the

14   base transceiver stations may perform these hand off processing functions.

15   As with other processing functions, the software architecture 300 of the aircore

16   platform 200 is designed to use, as much as possible, generic processing for mobile

17   unit hand offs. Thus, communications from the mobile units operating according to

18   different protocols, e.g., GSM, TDMA, CDMA and AMPS are handled in a generic

19   fashion, except where specific differences are required. The message flows associated

20   with these protocols will be described later.

21   Referring to Figure 10, once a base station detects that the signal level has

22   either dropped below the minimum, or exceeded the maximum, to continue the call on

23   the current channel, hand off processing begins. Measurements are taken of bordering

24   systems to determine the best candidate system, or target base station. The HOP 416

25   is involved in this for analog protocols and some inter-system hand offs. Otherwise,

26   the step may be handled directly between the base station and the mobile unit. For

27   digital protocols, the base station sends the target information to the HOP 416 for

28   transmission to the CPM 414. For ISDN PRI + and DHD based analog protocols, the

29   HOP 416 determines the appropriate target for the hand off. Next, the CPM 414 is

1   notified via the HOP 416 of the required hand off and begins establishing a voice

2   circuit to the target system. Once confirmed, the CPM 414 sends the hand off

3   command to the current serving base station. This information is passed to the mobile

4   unit. The mobile unit confirms the reception of the target information and switches to

5   the new frequence and voice path. Upon arrival at the new frequency, the new serving

6   base station passes the confirmation to the CPM 414. The CPM 414 switches the

7   voice path during this process to the new channel and tears down the voice path to the

8   old serving system.

9   As noted above, the HOP 416 preprocess is limited. After the hand off is in

10   progress, the HOP 416 is no longer involved. Call processing uses the information

11   provided by the HOP 416 to establish appropriate resources to complete the hand off.

12   Call processing is responsible for the control of the remaining portion of the hand off.

13   For ISDN PRI+ protocol hand offs, a message is sent to the aircore platform

14   200 from a base station to indicate that a mobile unit requires a hand off. The

15   message specifies a protocol discriminator, a call reference (whose value is assigned

16   in a SETUP message), a message type and a user identification. The aircore platform

17   200 in turn sends a hand off message request to the base station to request the base

18   station measure a specific frequency. Finally, the base station sends a message to the

19   aircore platform 200 to report the measured strength of the signal recorded on the base

20   station.

21   ISDN PRI+ processing requires that the HOP 416 accept a hand off request

22   from the DHI 503. Appropriate hand off related information, including call reference

23   and RF channel, for example, is stored in the air core platform 200. The call reference

24   is a number that is retrieved from the device handler thread data that is initially stored

25   when call setup takes place. The RF channel is also retrieved from the device handler

26   thread data. The air core platform 200 then sends measurement requests to

27   appropriate boarder cells, sets a measurement request timer, and processes responses

28   from the base station.

1   For DHD based protocol hand offs, the HOP 416 accepts a hand off request

2   from one of the device handlers in the aircore platform 200. The appropriate hand off

3   related information, including the call reference and RF channel, for example, are

4   stored. The aircore platform 200 allocates a voice channel and sends measurement

5   requests (SCANs) to the appropriate border cells, sets a measurement timer, and

6   processes responses received from the base stations. For base stations not chosen for

7   hand off, the aircore platform 200 initiates a channel release. If a suitable target cell is

8   determined, the HOP 416 send the information to the CPM 414 for hand off.

9   For DHD based protocol hand off processing, a voice channel is assigned to

10   each base station when the measurement process takes place. For example, if three

11   base stations border the current wireless system and a measurement is to be taken, a

12   voice channel is explicitly reserved in each base station. When the target base station

13   is chosen, the voice channels in the other base stations must be released. To

14   accomplish this release, the device handlers will allocate and release the appropriate

15   channels for the measurements in accordance with commands sent by the HOP 416.

16   If an allocation fails or there are no channels available in a base station, the device

17   handlers send allocation failure events to the HOP 416, and the HOP 416 removes the

18   base station from the candidate list for the current hand off.

19   IS-634 analog hand off processing requires the HOP 416 to send a

20   measurement request to the AIM 430. The measurement request is then sent to

21   appropriate border cells. The measurement requests are sent back to the requesting

22   base station, and the information is forwarded to the HOP 416, for determination of

23   the target cell.

24   The strength measurement message is transferred to cells that are listed in a

25   Cell Identifier List parameter that is sent in the message. The HOP 416 stores the

26   reference number against the requesting base station so the return messages find the

27   correct base station. The reference number is timed in accordance with a base station

28   timer for measurement collection. Responses received after timer expiration are

29   discarded.

1   IS-634 TDMA hand off processing requires that the HOP 416 determine,

2   based on information received from the base station in a hand off required message,

3   the appropriate candidate cell. The HOP 416 then sends the appropriate information

4   to the CPM 414. If the HOP 416 does not find a suitable target cell, the hand off is

5   aborted.

6   IS-634 CDMA hand off processing requires the that HOP 416 determine an

7   appropriate target cell, based on information received by the HOP 416 from the base

8   station. The HOP 416 aborts the hand off if a suitable target cell is not determined.

9   GSM hand off processing requires that the HOP 416 use information received

10   from the base station in the hand off required message to determine appropriate target

11   cells. Once again, the HOP 416 aborts the hand off if a suitable target cell is not

12   located.

13   For hand off processing from a multiple protocol base station, the message

14   flows to the HOP 416 indicate the appropriate protocol of the mobile unit. For

15   intersystem hand offs, messages related to the intersystem hand off preprocessing are

16   sent from the HOP 416 to the IMH 432 and from the IMH 432. The border cell for

17   measurement may be reached in the same manner as sending a message to multiple

18   cell sites, except that the messages are intersystem. Therefore, the messages are sent

19   to the IMH 432, or are received from the IMH 432 instead of the AIM 430 base

20   station threads, DHI 503 or DHD 501.

21   Each cell supporting hand off in the aircore system 106 must have an

22   associated list of border cells that are contacted in the event of a hand off attempt.

23   These cells may have an identity that ties the cells to a link. These cells also have a

24   protocol that the HOP 416 and the CPM 414 can use for determining message

25   destination, supported protocols, and associated trunk groups, all of which may be

26   used for new voice circuit allocations.

27   Because the aircore platform 200 is capable of processing a number of

28   different protocol messages, some mechanism must be provided to determine the

29   correct protocol. For messages received from a single-protocol BSS, the aircore

1   platform 200 determines the correct protocol by reference to the protocol established

2   for that particular BSS. The BSS is then associated with a signaling link mechanism

3   that connects the BSS to the MSC 210. The link may be a SS-7 base, TCP/IP, LAPD,

4   CAS and ATM, for example. The MSC 210 associates the type of protocol supplied

5   by the BSS to any incoming messages received from the BSS. The actual protocol for

6   the base station is determined when the link to the BTS or BSS is brought into service.

7   One example is when the DH-7 510 spawns a thread connecting the BSS to the MSC

8   210.

9   To ensure signaling messages used with the aircore platform 200 perform the

10   same generic function across protocols, tables of messages may be used for different

11   aircore platform functions. The table that follows shows some of the messages used

12   for call processing in the aircore platform 200, and the accompanying messages

13   according to specific protocols.

Internal AireCore Call Processing Event	GSM (Euro and US)	IS-634 CDMA	IS-634 TDMA	IS-634 AMPS
CPM_PAG_PAGE_MOBILE	Page Request	Page Request	Page Request	Page Request
PAG_CPM_PAGE_RESPONSE	Page Response	Page Response	Page Response	Page Response
MAKE_CALL	Setup	Setup	Setup	Setup
CALL_RECEIVED	Setup	Setup	Setup	Setup
ROUTE_CALL	Assignment Complete	Assignment Complete	Assignment Complete	Assignment Complete
ALERT_CALL	Alerting	Alerting	Alerting	Alerting
CALL_ALERTING	Alerting	Alerting	Alerting	Alerting
CONNECT_CALL	Connect	Connect	Connect	Connect
CALL_CONNECTED	Connect	Connect	Connect	Connect
CLEAR_CALL	Disconnect	Disconnect	Disconnect	Disconnect
CALL_DISCONNECTED	Disconnect	Release	Release	Release
CLEAR_CALL	Release	Release/Release Complete	Release/Release Complete	Release/Release Complete
CALL_CLEARED	Release Complete	Release Complete	Release Complete	Release Complete

1   Calls may fall into one of several scenarios, including mobile originated (a

2 mobile unit originates the call), mobile terminated (a call to a mobile unit) and PSTN

3 originated, for example. Mobile originated calls may be received at the MSC and may

4 be originated at another wireless system (intersystem). Mobile originated calls may

5 also be received at a BTS and may then be passed to the MSC.

6   The aircore platform 200 initiates a location update sequence to register a

7 mobile unit with the aircore platform 200. A customer profile is retrieved from the

8 VLR 422 or HLR 424 as necessary. Once a customer profile is retrieved, the

9 procedures for call setup across the protocols is generic. The use of a standard

10 internal set of procedures allows the call processing of the aircore platform 200 to be

11 independent of the type of interface used when establishing the call. The events that

12 are specific to a particular protocol are handled by individual components of the AIM

13 430. A CALL_RECEIVED message announces arrival of an incoming call to the

14 CPM 414. When this message is sent, the customer profile is included as well as the

15 selected traffic channel. The CALL_RECEIVED message is sent based on proper

16 profile retrieval, authentication and channel selection. A ROUTE_CALL message is

17 sent to the CPM 414 as an indication that the call may be routed to the network since

18 the traffic channel allocation to the originating mobile unit was successful. The

19 ROUTE_CALL message is sent based on proper channel assignment for the call. An

20 ALERT_CALL event is received from the CPM 414 as an indication that the far end of

21 the call is in the alerting state. When this event is received, an alert message is sent to

22 the mobile unit. A CONNECT_CALL event is received as an indication that the far

23 end has connected the call. This indication is passed on to the mobile station in the

24 connect message. The above four events are used between the CPM 414 and all other

25 subsystems for call originations in the system.

26   Mobile termination also uses a set of generic events and/or messages.

27 However, mobile termination is more of a challenge than mobile origination, since the

28 current operating mode of a subscriber is not known prior to querying the relative

1   databases. Similar to the mobile origination procedure and the location updating

2   procedure, mobile termination is generic for all base station-type interfaces regardless

3   of the protocol. The first query is to the HLR 424 via the IMH 432. Call processing

4   sends an event to the IMH 432 requesting the current location of the customer and

5   how to reach the customer. This request is sent without indication of the intrasystem

6   protocol to use. The IMH 432 utilizes the MIN/MSISDN to HLR mapping table to

7   determine a protocol and location of the HLR in the network.

8   For an internal HLR, the event is built and sent to the HLR 424 for processing.

9   The protocol indicator is set based on the mapping table and a search is performed to

10   locate the customer profile in the HLR database. If the customer profile is not found,

11   the HLR 424 can optionally query the opposite side of the database in the case where

12   the phone supports multiple modes and protocols. Once found, the VLR 422 is

13   contacted (if not local) via standard procedures, such as ROUTE_REQUEST or

14   PROVIDE_ROAMING_NUMBER.

15   For call tear down, the aircore platform 200 is based on the ISDN model for

16   call release. This scenario is a three message sequence beginning with the requesting

17   interface presenting notification of a disconnect. The notification is followed with a

18   two event exchange with all involved subsystems for the call to command the release

19   of the call and a return message to confirm the release. Low level processing in the

20   aircore platform 200 ranges from changing the state of supervision bits to a two or

21   three message exchange.

22   Figure 29a shows the basic components of the aircore platform 200 that are

23   involved in call processing in the above scenarios. As shown in Figure 29a, calls to

24   the aircore platform 200 may be received at a device handler such as the DH-7 510.

25   The device handler DH-7 510 may communicate with the IMH 432 and the AMH

26   431. The VLR 422 and the HLR 424 and AC/AuC (not shown) may be addressed by

27   the IMH 432 to retrieve customer-specific data and to perform other functions,

28   including customer location, for example. The CPM 414 communicates with the ARS

29   434, the IMH 432 and the PAG 435.

1   The components shown in Figure 29a communicate via a set of generic

2   messages. These messages indicate receipt of a call, authentication, call routing and

3   call connection, for example.

4   To ensure proper tracking of a call and the call's processing, whenever a call

5   comes into the aircore platform 200, the AMH 431 receives a notification from the

6   DH-7 510. The AMH 431 accesses the decoder thread to decode the incoming

7   message and to determine the appropriate action. If the message is the first message

8   associated with a call, the AMH 431 allocates an area in the common memory 439,

9   with an index to that area. For the duration of the call processing and the call, the

10   designated area will be used as needed during the transaction processing. For

11   example, the designated area includes the customer identification number and the base

12   station identification.

13   The AMH 431 can spawn threads unique to base station protocols such as

14   GSM or RDMA, TDMA, or AMPS. The AMH 431 may also spawn different threads

15   depending on the manufacturer of a mobile unit.

16   The IMH 432 works in a fashion similar to that of the AMH 431 in that the

17   IMH 432 spawns different threads, depending on the protocol required for the system

18   (GSM or IS-41). When the IMH 432 deals with internal events, it shares the index

19   and memory space used by the associated AMH 431. The IMH 432 pulls the message

20   from the memory space of the common memory 439 created by the AMH 431, using

21   the index created by the AMH 431.

22   The IMH 432 also processes events without the involvement of an AMH 431

23   thread. For these situations, the index and memory area are allocated by the IMH 432

24   thread. Memory and index allocation are coordinated within the AIM 430 subsystem.

25   The ARS 434 communicates with the VLR 422 via the IMH 432 thread to

26   retrieve the requisite information to authenticate the subscriber and determine the

27   validity of the transaction. The processing of the ARS 434 thread is made generic.

28   The PAG 435 thread tracks the outstanding page requests that are in process

29   for the system. The PAG 435 thread receives incoming PAGE_MOBILE events from

1   the CPM 414 when a mobile unit is to be paged on the aircore system. The PAG 435

2   thread determines the appropriate base station resources that should be sent the PAGE

3   message. The PAGE_REQUEST message is then communicated to the appropriate

4   AMH 431 threads for processing. In a multi-protocol environment, the decision on

5   the base stations that receive the PAGE_REQUEST event is based on the last known

6   technology that the mobile unit was operating on. If a mobile unit has GSM and

7   CDMA capabilities, and the last activity for the mobile unit was on the GSM portion

8   of the system, the PAG 435 thread will process this as a GSM based paging. If

9   however, there is not a last known technology for the mobile unit, all technologies

10   within the mobile unit's capabilities are paged. If the mobile unit referenced above did

11   not have a last known technology, both the CDMA and the GSM based paging would

12   take place. Once the PAGE_RESPONSE message is received, the AMH 431 thread

13   decodes the message and sends the decoded data, via the common memory 439 to the

14   PAG 435 thread where an association is made between the incoming

15   PAGE_RESPONSE and the previous outgoing PAGE_REQUEST messages. Based

16   on the responding base station, the appropriate technology can be determined. The

17   determination of the proper protocol at this point is much like the determination used

18   for mobile originated actions. The responding base station determines the protocol

19   based on its capabilities that were known when the interface to the base station was

20   brought into service.

21   Call processing also uses a common reference scheme to track all events

22   associated with a call. This scheme is illustrated in Figure 29b. Each call placed with

23   the aircore platform 200 leads to creation of a session 490 with a session object header

24   491. The session object header 491 is created based on an index number generated

25   from the board, span, and channel used for the first party involved in the call. Board,

26   span and channel is a reference created relative to the physical interface used for

27   system access. The session 490 adds and removes call objects 492, as dictated by the

28   progression of the call. Each session 490 has a reference number for the session that

29   is based on the originator's board span and channel. However, the session may also

1   be indexed by an index number of the board, span and channel of any of the parties

2   involved in the session. As shown in Figure 29b, each party object has its own data

3   related to the customer or the interface to which it is related.

4   The authentication process may be initiated as a result of either a service

5   request by a mobile unit or following the successful page of a mobile unit, but is

6   performed primarily under the control of the VLR. The authentication process may be

7   set up to be performed every time a mobile unit originates a call or when a call

8   terminates at a mobile unit. Authentication may also take place whenever a location is

9   updated for the mobile unit that is in a power on or an idle state. Finally,

10   authentication may occur when a mobile unit registers by turning power on.

11   When a mobile unit originates a request for service, the mobile unit sends a

12   message to the MSC, including the IMSI, a mobile identification number (MIN), or a

13   temporary mobile subscriber identification (TMSI). The MSC may use the IMSI, the

14   MIN, or the TMSI as the primary identification for the mobile unit. The IMSI is a

15   permanent number that is assigned to every mobile unit. The MIN is a permanent

16   number assigned to a mobile unit in the case where an IMSI is not used. (MIN is used

17   in older AMPS based mobile units). The TMSI is assigned to a mobile unit only after

18   an authentication, and has only local significance. If the TMSI is not recognized from

19   the mobile unit, then a request is made to use the IMSI to continue the authentication.

20   Upon successful authentication, a new TMSI (if used) is assigned to the mobile unit

21   for future system access.

22   The authentication center is the source of data used in authentication. The

23   authentication center does not store data for the customers. Instead, the authentication

24   performs calculations using random numbers that are used in conjunction with data in

25   the HLR to generate authentication data. When a customer first subscribes for

26   service, the customer is assigned a secret key (K_i for GSM, A-key for CDMA,

27   TDMA). The key and a random number supplied by the authentication are used by

28   the authentication center to generate a result. The data calculations also yield values

29   used for encryption keys. Depending on the protocol (GSM or IS-41 based), the

1   authentication process can occur at different times during the establishment of

2   communications between the mobile unit and the MSC 210. The similarities between

3   the authentication procedures are found in the fact that they produce results that are

4   used for both access verification and encryption. Although the security calculations

5   the responsibility of the authentication center, the initiation of the actual

6   collection/transmission of data and the comparison to determine the validity of the

7   access is the responsibility of the ARS 434 thread.

8   When authentication is requested, the MSC sends the random number of the

9   mobile unit. The mobile unit retrieves the K_i from its initialization memory and

10   calculates a signed response (SRES) and an encryption key K_c. The mobile unit then

11   stores the K_c and sends the SRES to the MSC. The ARS 434 identifies that the SRES

12   sent by the mobile unit matches the SRES calculated by the ARS 434. If the values

13   match, the value of K_c stored in the mobile unit is assumed to be correct. This

14   authentication process does not require that the encryption key K_c or the initial key K_i

15   be transmitted over the air, thereby ensuring security for the encryption process.

16   An example of the GSM authentication process is described with reference to

17   Figure 29c. The authentication process starts with step S10. The process then moves

18   to step S12 where a mobile unit sends a service request message to the aircore

19   platform 200. The message includes the temporary mobile subscriber identification

20   (TMSI). The process them moves to step S14. In step S14, the ARS 434 compares

21   the TMSI sent from the mobile unit to the TMSI recorded in the VLR 422. If the ARS

22   434 recognizes the TMSI, the process moves to step S20. Otherwise the process

23   moves to step S16.

24   In step S16, the ARS 434 requests the IMSI for the mobile unit from the VLR

25   422. The process then proceeds to step S20. In step S20, the aircore platform 200

26   sends a message to the mobile unit indicating that the mobile unit is recognized. The

27   process then moves to step S24.

28   In step S24, the mobile unit sends an authentication request message to the

29   aircore platform 200. The process then moves to step S28. In step S28, the aircore

1   platform 200 sends a random number to the mobile unit and the authentication center

2   platform 200 sends a random number to the mobile unit and the authentication center

3   calculates a signed response (SRES) based on the random number. The process then

4   moves to step S30.

5   In step S30, the mobile unit, after receiving the random number, retrieves the

6   case K_i from its initialization memory and calculates the SRES and the encryption key

7   K_c. The process then moves to step S34. In step S34, the mobile unit stores the

8   encryption key K_c and sends the SRES to the aircore platform 200. The process then

9   moves to step S38. In step S38, the ARS 434 compares the SRES calculated by the

10   mobile unit with that calculated authentication center 200. If the two SRESs match,

11   the process moves to step S44. Otherwise the process moves to step S40. In step S40,

12   the aircore platform 200 sends a message to the mobile unit indicating that the

13   authentication failed.

14   In step S44, the ARS 434 completes the authentication process. The process

15   then moves to step S48. In step S48, the ARS 434 determines if the mobile unit needs

16   a TMSI. If the mobile unit needs a TMSI, the process moves to step S50. In step S50,

17   the ARS 434 assigns a TMSI to the mobile unit and stores the value of the TMSI in

18   the VLR 422. The process then moves to step S60. In step S60, the authentication

19   process ends and call processing continues. The message flows associated with a

20   failed authentication are shown in Figure 58.

21   The above-described authentication process is the GSM authentication

22   procedure, which is one of several authentication procedures available to the MSC.

23   Other authentication processes may vary according to the call processing protocol, for

24   example.

25   The operation of the aircore platform 200 in a multi-protocol wireless

26   environment is explained below with reference to Figures 30-72.

27   When the aircore platform 200 and base station controllers are first brought on

28   line, they exchange messages to ensure that all circuits are properly aligned. Figure 30

29   shows the reset and reset acknowledgment function when the base station controller is

1   started. In Figure 30 base station controller (BSC) 105 sends a reset message 620 to

2   the device handler DH-7 510 to initiate the message sequence. The DH-7 510

3   transfers the message to the AMH 431 using DH-7_AMH_TRANSFER 621. The

4   AMH 431 then sends an AMH_REC_RESET 622 to the REC 402 to initiate the reset.

5   The REC 402 returns a reset acknowledge to the BSC 105 using the

6   REC_AMH_RESET_ACK 623, which is sent to the AMH 431. The AMH 431

7   transfers the reset acknowledgment to the DH-7 510 using AMH_DH-7_TRANSFER

8   624. The DH-7 510 then sends a RESET_ACK 625 to the BSC 105. The BSC 105

9   then sends a BLOCKING or CIRCUIT_GROUP_BLOCK 626 to the DH-7 510. The

10   DH-7 510 sends a DH-7_AMH_TRANSFER 627 to the AMH 431, which in turn sends

11   an AHM_REC_ BLOCKING or AMH_REC_CIRCUIT_GROUP_BLOCKING 628 to

12   the REC 402. This process then continues until all the circuits are in the appropriate

13   state on the side of the aircore platform 200.

14   Figure 31 shows the reset and reset acknowledgment message flows for a base

15   controller failure. The message flows are similar to those shown in Figure 30.

16   Figure 32 shows the message flows for the start up of the aircore platform 200.

17   Upon startup, the REC 402 sends a REC_AMH_RESET 640 to the AMH 431. The

18   AMH 431 transfers the reset message to the DH-7 510, using an AMH_DH7_

19   TRANSFER 641, and starts a T16 timer 644 using AMH_TMR_SET_TIMER (RESET)

20   643. The reset signal (RESET 642) is then sent to the BSC 105. The BSC 105

21   returns a RESET_ACK 645 to the aircore platform 200 and the AMH 431 releases the

22   T16 timer 644 using AMH_TMR_RLS_TIMER (RESET) 647. The AMH 431 then

23   passes the reset acknowledgment to the REC 402 using AMH_REC_RESET_ACK 648.

24   Finally, the BSC 105 indicates blocking or circuit group blocking by sending an

25   appropriate message to the aircore platform 200. This process continues until all the

26   circuits are in the appropriate state on the side of the aircore platform 200.

27   Figure 33 shows the message flows for startup of the aircore platform 200 in

28   the event of a circuit failure.

1   Figure 34 shows the message flows for startup of the aircore platform 200 in

2   the event the T16 timer 644 times out before the BSC 105 returns a reset

3   acknowledgment message to the aircore platform 200.

4   The aircore platform 200 may interface with other wireless systems. To set up

5   a call, trunks are established between the two systems. Figures 35-40 are flow charts

6   that show the message traffic used to establish and reset the trunks. Figure 35 shows

7   the message flows when a far end system sends a blocking request to the aircore

8   platform 200. A blocking 700 is received from the BSC 105 and transferred to the

9   REC 402. The REC 402 returns a REC_AMH_BLOCKING_ACK 703 to the BSC 105.

10   The state of the trunk circuit established could move to blocked or to blocked pending

11   depending on whether a call is currently on the channel. The REC 402 assures the

12   appropriate state changes occur.

13   Figure 36 shows the message flows for resetting a trunk circuit when no call is

14   in progress. The BSC 105 sends a RESET_CIRCUIT 710 which is received at the

15   REC 402. The REC 402 returns a REC_AMH_RESET_CIRCUIT_ACK 714 to the

16   BSC 105 and the circuit is reset.

17   If a call existed on the trunk circuit, the message flows vary from that shown in

18   Figure 36. Figure 37 shows the message flows in this situation. In Figure 37, the

19   BSC 105 sends a RESET_CIRCUIT 720, which is transferred to the REC 402. The

20   REC 402 sends a REC_CPM_CLEAR_CALL 723 to the CPM 414. The CPM 414

21   sends a CLEAR_CALL 724 to the AMH 431. The AMH 431 then clears the call. In

22   parallel, the REC 402 sends a REC_AMH_RESET_CIRCUIT_ACK 725, which is

23   transferred (726, 727) to the BSC 105.

24   The trunk circuit may also be reset by action taken by the aircore platform 200.

25   Figure 38 shows the message flows in this situation. The REC 402 initiates a

26   REC_AMH_RESET_CIRCUIT 730, which is transferred (736, 738) to the BSC 105.

27   The AMH 431 sets the T12 timer 734 using an AMH_TMR_SET_TIMER (RESET_

28   CIRCUIT) 733. The BSC 105 returns a reset circuit acknowledgment using

29   RESET_CIRCUIT_ACK 735, which is transferred (736, 738) to the REC 402.

1   Because the REC 402 received the reset circuit acknowledgment before expiration of

2   the T12 timer 734, the AMH 431 sends (737) a timer release message to the TMR 437

3   releasing the T12 timer 734.

4   In some cases, the BSC 105 will not return a reset circuit acknowledgment

5   message before expiration of the T12 timer 734. Message flows in this situation are

6   shown in Figure 39. When the T12 timer 734 times out, AMH 431 (747) sends a time

7   out message to the REC 402. The REC 402 then repeats the reset circuit procedure n

8   number of times, where n is a setable parameter. When the nth attempt to reset the

9   trunk circuit fails, an alarm is raised at the Operations and Maintenance system. The

10   far end state of the circuit remains in an unknown state.

11   Figure 40 shows the message flows associated with opening a trunk circuit.

12   The message flows are similar to those in Figure 35.

13   The aircore platform 200 maintains the current location of mobile customers

14   using the VLR 422 and HLR 424. When a mobile customer enters the region serviced

15   by the aircore platform 200, the mobile customer's mobile unit 112 will register with

16   the aircore platform 200. Figures 41 through 47 show the message flows associated

17   with this registration process.

18   Figure 41 shows the message flows associated with the successful updating by

19   location of a mobile unit 112. The flow assumes the mobile unit's profile has been

20   previously retrieved and is stored in the VLR 422, and therefore no interaction is

21   shown with the HLR 424. The BSC 105 sends (760) a location update request to the

22   aircore platform 200. The request is received at the DH-7 510, which transfers (761)

23   the update request.

24   At the ARS 434, the update request triggers authentication processing if the

25   mobile unit 112 operates according to IS-41 protocols. The update request is then

26   passed (763, 764) to the VLR 422. The VLR 422 updates the active file for the

27   mobile unit 112 and returns a VLR registration notification response to the BSC 105.

28   When the VLR registration notification response reaches the ARS 434, GSM

29   authentication and ciphering are completed, if the mobile unit 112 operates according

1   to GSM protocols. The BSC 105 receives a LOCATION_UPDATING_ACCEPT 769

2   message from the DH-7 510. The DH-7 510 also provides a CLEAR_COMMAND

3   771 to the BSC 105. At this time, GSM TMSI reallocation occurs. The BSC 105

4   sends a CLEAR_COMPLETE 772 to the DH-7 510, which in turn sends a DH-7_

5   AMH_TRANSFER 773 to the AMH 431.

6   Figure 42 shows the message flows associated with location updating in the

7   event the registration notification request is rejected. Figure 43 shows the message

8   flows if the mobile unit 112 powers down while operating in the vicinity of the aircore

9   platform 200.

10   Figure 44 shows the message flows associated with a periodic update in which

11   the mobile unit 112 is already registered in the local VLR with the subscriber profile

12   already having been retrieved from the HLR. The BSC 105 sends a LOCATION_

13   UPDATE_ REQUEST 1400, which is transferred (1401) to the AMH 431. The AMH

14   431 sends an AMH_ARS_LOCATION_UPDATING_REQUEST 1402 to the ARS

15   434. At this point, authentication may be performed (1404) for IS-41 protocol

16   equipment. The ARS 1406 then sends an ARS_IMH_AUTHENTICATION_

17   REQUEST 1406 to the IMH 432. The IMH 432 then sends an IMH_VLR_

18   REGNOT_REQUEST 1408 to the VLR 422.

19   The mobile unit 112 was previously registered in the VLR 422. Therefore, the

20   mobile unit's location is simply updated, and a VLR_IMH_REGNOT_RESPONSE

21   1410 is returned to the IMH 432. The IMH 432 sends an IMH_ARS_

22   AUTHENTICATION_RESPONSE 1412 to the ARS 434, which in turn sends (1414)

23   and authentication result to the AMH 431. The AMH 431 then sends (1416) a

24   LOCATION_UPDATING_ACCEPT 1418 to the BSC 105. The aircore platform 200

25   may also perform GSM authentication and ciphering (1413) and TMSI reallocation

26   (1419).

27   The AMH 431 sends (1421) a CLEAR_COMMAND 1420 to the BSC 105.

28   The BSC 105 returns a CLEAR_COMPLETE 1422 to the DH-7 510, which sends a

29   DH7_AMH_TRANSFER 1423 to the AMH 431.

1   Figure 45 shows the message flows associated with location updating in which

2   the mobile unit is not currently listed in the local VLR, but is listed in the local HLR.

3   The initial message flows 1430 - 1438 are the same as shown in Figure 44 (1400 -

4   1408), including authentication (1434) for IS-43 protocol systems. However, the

5   mobile unit 112 is not listed in the VLR 422. The VLR 422 returns a VLR_IMH_

6   REGNOT_ RESPONSE 1440 that indicates the mobile unit 112 is not registered in

7   the VLR 422. In response, the IMH 432 sends an IMH_HLR_REGNOT_REQUEST

8   1442 to the HLR 424. The mobile unit 112 is registered in the HLR 424, and the HLR

9   424 returns an HLR_IMH_REGNOT_ RESPONSE 1444 to the IMH 432. The IMH

10   432 then sends an IMH_VLR_ REGNOT_RESPONSE 1446 to the VLR 422 to

11   register the mobile unit 112 in the VLR 422. In response, the VLR 422 returns a

12   VLR_IMH_REGNOT_ RESPONSE 1448 to the IMH 432 to indicate that the mobile

13   unit 112 is registered in the VLR 422. The remaining message flows (1450 - 1464)

14   are similar to those (1412 - 1422) shown in Figure 44.

15   Figure 46 shows the message flows when the IMH 432 determines that the

16   mobile unit 112 is homed to an external HLR. The IMH 432 makes this

17   determination based on an identification of the mobile unit 112 that is provided with

18   the initial location update request messages. In Figure 46, the initial message flows

19   (1480 - 1488) are similar to those shown in Figure 44. The VLR 422 notifies the IMH

20   432 that the mobile unit 112 is not registered in the VLR 422. Based on the

21   identification of the mobile unit 112, the IMH 432 then determines that the mobile

22   unit 112 is registered in an external HLR. The identification is used to locate the

23   external HLR. The IMH 432 sends a MAP_UPDATE_LOCATION_INVOKE

24   (GSM) or a REGISTRATION_ NOTIFICATION_INVOKE (IS-41) 1492, 1493 to the

25   external HLR. The IMH 432 also sets a REGNOT timer 1496. The external HLR

26   returns (1494) a MAP_UPDATE_LOCATION_RESULT (GSM) or a

27   REGISTRATION_NOTIFICATION_RETURN _RESULTS (IS-41) 1495 to the MSC

28   210. The IMH 432 releases the REGNOT timer 1496 and sends an IMH_VLR_

29   REGNOT_RESPONSE 1498 to the VLR 422, causing the mobile unit 112 to be

1   registered in the VLR 422. The VLR 422 then returns a VLR_IMH_REGNOT_

2   RESPONSE 1499 to the IMH 432. The remaining message flows (1500 - 1509) are

3   similar to those shown in Figure 44.

4   Figure 47 shows the message flows when the IMH 432 determines that the

5   mobile unit 112 is homed to an external HLR, but the REGNOT timer 1496 times out

6   before the external HLR returns a response. The IMH 432 makes this determination

7   based on an identification of the mobile unit 112 that is provided with the initial

8   location update request messages. In Figure 47, the initial message flows (1510 -

9   1524) are similar to those shown in Figure 46. When the REGNOT timer 1496 times

10   out, the TMR 437 sends a TMR_IMH_TIMER(REGNOT) 1525 to the IMH 432. The

11   channel is cleared (1526 - 1535) in a manner similar to that in Figure 47.

12   Figures 48-71 show the message flows associated with call processing. Figure

13   48 is a flow chart for a mobile originated call. The mobile originated call begins when

14   the BSC 105 receives an indication from the mobile unit 112 that the mobile unit 112

15   will originate a call. The BSC 105 may receive the number of the called party that

16   was dialed at the mobile unit 112.

17   The BSC 105 transmits a CM_SERVICE_REQUEST 800 to the aircore

18   platform 200 where the message is received and processed by the DH-7 510. The

19   DH-7 510 establishes the SS-7 link and ensures proper message routing for the

20   inbound message. The DH-7 510 sends a DH-7_AMH_TRANSFER 801 to the

21   appropriate AMH 431 (either the GSM or the IS 634 thread). The AMH 431 sends an

22   AMH_ARS_CM_SERVICE_REQUEST 802 to the ARS 434.

23   The ARS 434 provides the appropriate calculations and processing to

24   authenticate the given base station interface. The ARS 434 then sends an

25   ARS_IMH_AUTHENTICATION_REQUEST 803 to the appropriate IMH 432. The

26   IMH 432 sends an IMH_VLR_REGNOT_REQUEST 804 to the VLR 422 to notify the

27   VLR 422 of the incoming call. The VLR 422 registers the mobile unit 112 as an

28   active unit and then sends a VLR_IMH_REGNOT_RESPONSE 805 to the appropriate

29   IMH 432. The IMH 432 sends an IMH_ARS_AUTHENTICATION_RESPONSE 806

1   to the ARS 434. If the mobile unit 112 uses a GSM protocol, GSM authentication and

2   ciphering are completed at this point.

3   The ARS 434 sends an ARS_AMH_AUTHENTICATION_RESULT 807 to the

4   AMH 431 and the appropriate AMH 431 sends an AMH_DH-7_TRANSFER 808 to

5   the DH-7 510. The DH-7 510 sends a CM_SERVICE_ACCEPT 809 to the BSC 105

6   indicating to the BSC 105 that the mobile unit 112 is allowed to proceed with the call

7   processing using the aircore platform 200.

8   During the above-described processing for a GSM protocol mobile unit, the

9   ARS assigns the call a temporary mobile subscriber identity (TMSI). The TMSI is

10   calculated based on an index in the VLR 422, the time of day, and the identity (IMSI)

11   of the mobile unit 112. The TMSI provides additional security so that if the mobile

12   call is tapped, the identity of the calling mobile party cannot be determined.

13   In Figure 48, the mobile call process then proceeds to the call setup stage and

14   the BSC 105 transmits a SETUP 810 to the DH-7 510. The SETUP 810 includes the

15   call number and an identity of the mobile customer. The DH-7 510 transfers the

16   information to the appropriate AMH 431 by sending a DH-7_AMH_TRANSFER 811.

17   The AMH 431 then notifies the CPM 414 that a mobile originated call has been

18   received by sending a CALL_RECEIVED 812. When the CPM 414 is notified that the

19   mobile call has been received, the CPM 414 allocates a voice channel for a mobile

20   call to carry the voice between the aircore platform 200 and the BSC 105. The mobile

21   call is assigned a session number and each party of the mobile call is assigned an

22   object of the mobile call.

23   The AMH 431, the DH-7 510 and the BSC 105 communicate through a series

24   of messages 813-821 that the call assignment request has been made and completed.

25   During this processing, a T10 timer 818 is used to time out the call in the event a

26   voice channel cannot be readily assigned. Once the channel assignment is complete

27   and the radio and voice channels are assigned, the AMH 431 sends a ROUTE_CALL

28   822 to the CPM 414, informing the CPM 414 to proceed with the call because all of

29   the incoming wireless communication requirements have been established. The CPM

1   414 determines, based on the number that is to be dialed out, what facility the call

2   should go to and in what format. The CPM 414 sends a MAKE_CALL 823 to the

3   appropriate device handler (DHD 501, DHI 503 or DH-7 510) for a land-based or

4   wired call. If the number to be dialed is for a mobile unit, the CPM 414 sends a

5   location request (not shown) through the IMH 432 to the HLR 424 to find out where

6   the called mobile customer is.

7   As shown in Figure 48, the device handler returns a CALL_ALERTING 824 to

8   the CPM 414 indicating an attempt to connect to the called party. The alerting

9   message is then passed to the BSC 105 using an ALERT_CALL 825, AMH_DH-

10   7_TRANSFER 826 and an ALERTING 827.

11   After the MAKE_CALL 823 is transmitted, the called party should return a

12   signal to the appropriate device handler, which then sends a CALL_CONNECTED

13   828 to the CPM 414. The CPM 414 sends a CONNECT_CALL 829 to the AMH 431,

14   which propagates as a CONNECT 831 to the BSC 105. At the same time, the AMH

15   431 sets a T313 timer 833 using a AMH_TMR_SET_TIMER (CONNECT) 832 to the

16   TMR 437. The TMR 437 then waits for a connection acknowledgment that indicates

17   the called party and the calling party are connected. In particular, the BSC 105 sends

18   a CONNECT_ACK 834 to the DH-7 510, and the connect acknowledgment is

19   propagated (835) to the AMH 431. The AMH 431 then releases the T313 timer 833

20   by sending an AMH_TMR_RECS_TIMER (CONNECT) 836 to the TMR 437. At this

21   point, the mobile originated call is connected.

22   Figure 49 shows call processing for normal mobile termination. The aircore

23   platform 200 receives a call at a device handler 501 or 503. The device handler sends

24   a CALL_RECEIVED 840 to the CPM 414. The CPM 414 forwards a CPM_IMH

25   LOCATE_SUBSCRIBER 841 to the IMH 432 initiating a subscriber location action

26   (not shown) in which the HLR 424 (not shown) is queried to determine the location of

27   the called mobile unit 112. The IMH 432 returns an IMN_CPM_SUBSCRIBER_

28   LOCATION 842 to the CPM 414 indicating the location of the mobile 112 unit within

29   the wireless area served by the aircore platform 200. The CPM 414 then initiates a

1   CPM_PAG_PAGE_MOBILE 843 to the PAG 435 to page the called mobile unit 112.

2   The called mobile unit 112 is then paged (845, 846) and returns a response (850-852).

3   At the same time, the AMH 431 initiates a timer 855 that will timeout the page

4   request if a page response from the mobile unit 112 is not received within a set time

5   period.

6   As shown in Figure 49, once the page response is received, the ARS 434

7   initiates an ARS_IMH_ AUTHENTICATION_REQUEST 853 to the IMH 432. The

8   IMH 432 sends an IMH_VLR_REGNOT_REQUEST 854 to the VLR 422 to retrieve

9   the profile information from the VLR 422 for the mobile unit 112. The VLR 422

10   returns a VLR_IMH_REGNOT_ RESPONSE 857 containing the requested data for the

11   mobile unit 112 in the VLR 422.

12   During the time period that the mobile unit 112 is being paged and the

13   authentication and registration notification messages are being passed, authentication

14   and ciphering, may occur. In particular, for IS-41 protocol systems, authentication

15   may occur at block 848. For GSM protocol systems, GSM authentication, ciphering

16   and TSMI reallocation may occur at block 859.

17   As shown in Figure 49, when the AMH 431 receives the authentication result,

18   the AMH 431 initiates an AMH_PAG_PAGE_RESPONSE 861 which is passed (862)

19   to the CPM 414. The CPM 414 then initiates a MAKE_CALL 863. The aircore

20   platform 200 then proceeds to call setup, channel assignment, alerting, call connection

21   and call connection acknowledgment (864-889).

22   Figure 50 shows a mobile terminated call in which no response is received to

23   the PAGE_MOBILE message, and the page timer times out. In Figure 50, the

24   messages 900-906 are similar to messages 840-846 of Figure 49. An

25   AMH_TMR_SET_TIMER (PAGE_RESPONSE) 907 is sent by the AMH 431 to the

26   TMR 437. When the AMH 431 fails to receive a response to the page request, the

27   timer 908 times out in the TMR 437, and the TMR 437 sends a TMR_AMH_TIMER

28   (PAGE_RESPONSE) 910 to the AMH 431. The AMH 431 then initiates a series of

29   messages 911 to 916 to update the VLR 422. The CPM 414 receives a PAGE_CPM_

1   PAGE_RESPONSE 918 indicating no response to the mobile page, and as a result the

2   CPM 414 does not issue a MAKE_CALL message.

3   Figure 51 shows the message flows associated with a PSTN initiated

4   disconnect. The device handler (DHD 501 or DHI 503) receives a disconnect signal

5   from a telephone or other device connected to the PSTN. The device handler sends a

6   DISCONNECT_CALL 930 to the CPM 414, which returns a CLEAR_CALL 932 to

7   the device handler and issues the CLEAR_CALL to the AMH 932. As a result, a

8   DISCONNECT (GSM) or RELEASE (IS-634) 934 is sent to the BSC 105, which

9   returns a RELEASE (GSM) or RELEASE_COMPLETE (IS-634) 938. A T305 or

10   T306 (GSM) or T308 (IS-634) timer 936 is also set in the TMR 437, and if the

11   RELEASE or RELEASE_COMPLETE 938 is not received before expiration of the

12   timer 936, the channel is released.

13   Once the RELEASE or RELEASE_COMPLETE 938 is received, the AMH

14   431 sends a CALL_CLEARED 944 to the CPM 414, and a RELEASE_COMPLETE

15   943 is sent to the BSC 105. The DH-7 510 then sends a CLEAR_COMMAND 946 to

16   the BSC 105, and an internal timer 948 is set in the TMR 437. The BSC 105 returns a

17   CLEAR_COMPLETE 949, and the internal timer 948 is released.

18   Figure 52 shows a mobile originated disconnect. A DISCONNECT (GSM) or

19   RELEASE (IS-634) 960 is received at the DH-7 510 from the BSC 105. The DH-7

20   510 transfers the message to the AMH 431, which initiates a DISCONNECT_CALL

21   962 to the CPM 414. The CPM 414 initiates a CLEAR_CALL 964 to the AMH 431

22   and the device handler 501 or 503. The AMH 431 transfers (965) the CLEAR_CALL

23   964 command to the DH-7 510, which initiates a release (GSM) or RELEASE_

24   COMPLETE (IS-634) 966. The device handler 501 or 503 sends a CALL_CLEARED

25   967 to the CPM 414. The AMH 431 also initiates a T308 timer 964 (GSM) to clear

26   the channel in case a RELEASE_COMPLETE message is not received from the

27   mobile unit 112 within the time period set by the T308 timer 964. The BSC 105

28   returns a RELEASE_COMPLETE (GSM) 970 to indicate that the mobile unit 112 has

29   completed disconnect, and the AMH 431 releases the T308 timer 964 and sends a

1   CALL_CLEARED 975 to the CPM 414. The AMH 431 sends an AMH_DH-

2   7_TRANSFER 967 to the DH-7 510, which initiates a CLEAR_COMMAND 977 to

3   the BSC 105. The AMH 431 also sets an internal timer 980 to clear the channel in the

4   event that a CLEAR_COMPLETE message is not received from the BSC 105. The

5   BSC 105 then initiates a CLEAR_COMPLETE 978 and the AMH 431 releases (981)

6   the internal timer 980.

7   Occasionally, a base station may not return a response to the MSC 210 within

8   the timeout specified. The message flows for this situation is shown in Figure 53.

9   The message flow begins after the service request message flows shown in Figure 48

10   (messages 800 - 809) are completed. A SETUP 960 is sent from the BSC 105 and in

11   response, the AMH 431 sends a CALL_RECEIVED 991 to the CPM 414 and sets the

12   T10 timer 818. Because the BSC 105 does not return a response to the

13   ASSIGNMENT_ REQUEST 996, the T10 timer 818 times out and the AMH 431

14   sends a DISCONNECT_CALL 1000 to the CPM 414 to initiate a clear call sequence.

15   The CPM 414 sends a CLEAR_CALL 1001 to the AMH 431, which is passed (1002)

16   to the BSC 105 as a DISCONNECT (GSM) or RELEASE (IS-634) 1003. The AMH

17   431 also sets (999) a channel release timer 936 in order to release the channel if the

18   BSC 105 does not respond to the DISCONNECT 1003.

19   The BSC 105 then sends a RELEASE (GSM) or RELEASE_COMPLETE (IS-

20   634) 1004, which is transferred (1005) to the AMH 431. The AMH 431 releases

21   (1006) the timer 936, sends a CALL_CLEARED 1007 to the CPM 414, and sends

22   (1008) a RELEASE_COMPLETE 1009 (GSM) to the BSC 105. The AMH 431 then

23   sends (1010) a CLEAR_COMMAND 1011 to the BSC 105 and sets (1012) an

24   internal timer 1013. The BSC 105 returns a CLEAR_COMPLETE 1014, which is

25   transferred (1015) to the AMH 431, which then releases (1016) the internal timer

26   1013.

27   Figure 54 shows the sequence of a time out of the T10 timer 818 for a mobile

28   terminated call. The initial message flows are the same as messages 840 - 860 shown

29   in Figure 49 and are not repeated in Figure 54. The AMH 431 sends a

1   AMH_PAG_PAGE_ RESPONSE 1020 to the PAG 435, which is passed (1021) to

2   the CPM 414. The CPM 414 sends a MAKE_CALL 1022, which is passed as a

3   SETUP 1025 to the BSC 105. The BSC 105 returns a CALL_CONFIRMED 1027.

4   The T303 timer 869 is set (1026) and released (1028, 1029). The BSC 105 receives

5   an ASSIGNMENT_REQUEST 1031, and the AMH 431 sends an AMH_TMR_SET_

6   TIMER (ASSIGNMENT_REQUEST) 1032 to set the T10 timer 818. However, the

7   BSC 105 does not send a response to the ASSIGNMENT_REQUEST 1031, and the

8   T10 timer 818 times out. As a result, the AMH 414 sends a DISCONNECT_CALL

9   1036 to initiate tear down of the channel. The CPM 414 then sends a CLEAR_CALL

10   1037, and the channel teardown proceeds through several message sequences to

11   release the channel and to report that the call is cleared (1038 - 1054) in the same

12   manner as shown in Figure 53. Coincident with the CLEAR_CALL 1037, the CPM

13   414 may send the calling party an announcement to inform the calling party that the

14   call cannot be completed to the mobile unit 112.

15   Figure 55 shows the message flows associated with a mobile originated call

16   when the channel assignment fails. Channel assignment failure can occur for a variety

17   of reasons including when the BSC 105 and the MSC 210 do not agree on the state of

18   the channel, for example. The BSC 105 and the MSC 210 will not agree on the state

19   of the channel if the BSC 105 indicates the channel is blocked and the MSC 210

20   indicates the channel is unblocked, for example. The BSC 105 also may incur a

21   failure in the establishment of the radio portion of the connection.

22   In Figure 55, a service request is initiated using the same message sequence

23   (800 - 809) as shown in Figure 48. The BSC 105 then sends a SETUP 1060, which is

24   received at the DH-7 510. The message is transferred (1061) to the AMH 431, which

25   sends a CALL_RECEIVED 1062 to the CPM 414. The call proceeds through call

26   setup (1063 - 1065) until an ASSIGNMENT_REQUEST 1066 is sent to the BSC 105.

27   In this case, however, the BSC 105 returns an ASSIGNMENT_FAILURE 1070. As a

28   result, the MSC 210 proceeds with call tear down (1071 - 1090) in the same manner

29   as shown in Figure 53 (1002-1016).

1   Figure 56 shows the message flow associated with a mobile terminated call

2   when the channel assignment fails. In Figure 56, the initial messages (840 - 860)

3   shown in Figure 49 have already been completed. The AMH 431 then sends an

4   AMH_PAG_PAGE_RESPONSE 1095 to the PAG 435, which passes the message

5   (1096) to the CPM 414. The call setup phase begins with a MAKE_CALL 1097, a

6   SETUP 1101, a CALL_CONFIRMED 1103 and an ASSIGNMENT_REQUEST

7   1107.

8   The BSC 105 returns an ASSIGNMENT_FAILURE 1109, indicating, for

9   example, that the BSC 105 and the MSC 210 do not agree as to the state of the

10   channel allocated between the BTS and the MSC 210. The AMH 431 sends a

11   DISCONNECT_CALL 1112 to the CPM 414, which returns a CLEAR_CALL 1115.

12   Call tear down then proceeds in the same manner as shown in Figure 53.

13   Figure 57 shows the message flows associated with a call disconnect when the

14   CLEAR_COMMAND internal timer times out. For the PSTN initiated disconnect

15   and the mobile originated disconnect, the message flows are the same once the

16   CALL_CLEARED 1135 is sent by the AMH 431 to the CPM 414. The AMH 431

17   sends (1136) a CLEAR_COMMAND 1139 to the BSC 105 and sets (1137) a

18   CLEAR_COMMAND internal timer 1138. The BSC 105 does not respond with a

19   CLEAR_COMPLETE message, and the internal timer 1138 times out (1140)

20   releasing the channel.

21   Figure 58 shows the message flows when the MSC 210 rejects a CM service

22   request. The BSC 105 sends a CM_SERVICE_REQUEST 1145 to the MSC 210.

23   The DH-7 510 determines the protocol of the sending mobile unit 112 and spawns an

24   appropriate thread and forwards (1146) the CM_SERVICE_REQUEST 1145 to the

25   AMH 431. The AMH 431 sends an AMH_ARS_CM_SERVICE_REQUEST 1147 to

26   the ARS 434, which forwards an ARS_IMH_AUTHENTICATION_REQUEST 1148

27   to the IMH 432. The ARS in turn sends a registration notification (IMH_VLR_

28   REGNOT_REQUEST 1149) to the VLR 422. The VLR 422 returns a response

29   (1150) that rejects the service request. This response is passed (1151) to the ARS

1   434, which sends a CM_SERVICE_REQUEST 1152 to the AMH 431. The AMH

2   431 transfers (1153) the rejection to the BSC 105 as a CM_SERVICE_REJECT 1154.

3   Figure 59 shows the message flows associated with a mobile terminated call in

4   which the CPM 414 times out waiting for an alerting message from the AMH 431.

5   The initial message flows are the same as shown in Figure 49 (i.e., 840 - 860). The

6   AMH 431 sends (1155) a page response to the PAG 435, which forwards (1156) the

7   page response to the CPM 414. The CPM 414 sends a MAKE_CALL 1157 to the

8   AMH 431, which transfers (1158) the message as a SETUP 1159 to the BSC 105.

9   The CPM 414 also sets the T310 timer 876, waiting on receipt of an alerting message.

10   The BSC 105 returns a CALL_CONFIRMED 1165, which is passed (1166) to the

11   AMH 431. A channel assignment is then completed (1168 - 1172). However, the

12   BSC 105 does not send an alerting message to the MSC 210, and the T310 timer 876

13   times out in the CPM 414. As a result, the CPM 414 sends a CLEAR_CALL 1173 to

14   the AMH 431, which is passed (1174) to the BSC 105 as a DISCONNECT (GSM) or

15   a RELEASE (IS-634) 1175. The call tear down then proceeds (1210-1226) in the

16   same manner as shown in Figure 53 (1002 - 1016).

17   Figure 60 shows the message flows associated with a mobile terminated call in

18   which the call confirmed timer times out in the TMR 437. The initial message flows

19   are the same as those shown in Figure 49 (840 - 860). The AMH 431 sends an

20   AMH_PAG_PAGE_RESPONSE 1200 to the PAG 435, which forwards (1201) it to

21   the CPM 414. The CPM 414 sends a MAKE_CALL 1203 to the AMH 431 and sets

22   the T310 timer 876. The AMH 431 transfers (1204) the MAKE_CALL 1203 to the

23   BSC 105 as a SETUP 1205 and sets (1206) the T303 call confirmed timer 869 in the

24   TMR 437. However, the BSC 105 does not return a call confirmed message to the

25   MSC 210, and the T303 timer 869 times out (1207). The AMH 431 sends a

26   DISCONNECT_CALL 1208 to the CPM 414 and the CPM 414 responds with a

27   CLEAR_CALL 1209. The call tear down then proceeds (1210-1226) in the same

28   manner as shown in Figure 53 (1002 - 1016).

1   Figure 61 shows the message flows associated with a mobile terminated call in

2   which the call connect timer times in the CPM 414. The initial message flows are the

3   same as those shown in Figure 49 (840 - 860). The AMH 431 sends an

4   AMH_PAG_PAGE_RESPONSE 1230 to the PAG 435 and call set up proceeds

5   through make call, call confirmed and channel assignment (1231 - 1245). The BSC

6   105 then sends an ALERTING 1246, which is transferred (1247) to the AMH 431.

7   The AMH 431 sets (1248) a T301 call connected timer 883 in the CPM 414.

8   However, the BSC 105 does not return a connect message, and the T301 timer 883

9   times out. The CPM 414 sends a CLEAR_CALL 1250 to the AMH 431, and call tear

10   down proceeds in the same manner as shown in Figure 53 (1002 - 1016).

11   Figure 62 shows the message flows associated with a mobile originated call in

12   which the BSC 105 does not send a connect acknowledge message to the MSC 210

13   and the T313 connect acknowledge timer 833 times out. The initial message flows are

14   the same as shown in Figure 48 (800 - 809). The call proceeds through setup, channel

15   assignment, alerting and call connection (1270 - 1294). The AMH 431 sets (1293) the

16   T313 connect acknowledge timer 833. However, the BSC 105 does not return a

17   connect acknowledgment, and the T313 timer 833 times out (1297). The MSC 210

18   then proceeds through call tear down.

19   Figure 63 applies to GSM and IS-634. Figure 63 shows the message flows

20   associated with a call disconnect (mobile or PSTN originated) in which the T308

21   (GSM) release complete timer 964 times out. Similar message flows would exist for

22   IS-634 protocol equipment. The initial message flows are the same as shown in

23   Figure 51 or Figure 52. The CPM 414 sends a CLEAR_CALL 1300 to the AMH 431,

24   which is transferred (1301, 1302) to the BSC 105. The AMH 431 also sets (1303) a

25   T308 release complete timer 964. As shown in Figure 63, the BSC 105 does not

26   return a release complete message and the T308 timer 964 times out (1304). The

27   AMH 431 then sends (1305) a second RELEASE 1306 to the BSC 105 and sets

28   (1307) a second T308 timer 964'. The BSC 105 returns a RELEASE_COMPLETE

29   1308, and the AMH 431 releases (1310) the T308 timer 964'. If the T308 timer 964'

1   were to expire, the AMH 431 could release the transaction and send a call cleared

2   message to the CPM 414. The MSC 210 may then go through a call clear sequence.

3   Returning to Figure 63, the AMH 431 next sends a CALL_CLEARED 1315 to the

4   CPM 414, sends (1316) a CLEAR_COMMAND 1317 to the BSC 105, and sets

5   (1318) a clear command internal timer 1319. The BSC 105 returns a

6   CLEAR_COMPLETE 1320 to the MSC 210. The AMH 431 then releases the

7   internal timer 1319.

8   Figures 64 - 66 show the message flows associated with processing a dual tone

9   multiple frequency (DTMF) signal. As shown in Figures 64 - 66, the BSC 105

10   initiates the processing by sending a START_DTMF (1330 in Figure 64) and the

11   CPM 414 returns a CPM_AMH_START_DTMF_ACK (1333 in Figure 64).

12   Figures 67-71 are flow charts showing message handling associated with call

13   processing with an HLR (internal or external).

14   Figure 67 shows the message flows when an incoming call is received at the

15   MSC 210, a location request is sent to the HLR 424, and the HLR 424 indicates that

16   the mobile unit 112 is operating locally. The DHI 501 sends a CALL_RECEIVED

17   1536 to the CPM 414. The CPM 414 sends a CPM_IMH_LOCATE_SUBSCRIBER

18   1537 to the IMH 432. The IMH 432 then sends an IMH_HLR_LOCATION_

19   REQUEST 1538 to the HLR 424. The HLR 424 returns a response (1539) indicating

20   that the mobile unit 112 is homed on the local system and is operating locally. The

21   IMH 432 then provides an IMH_CPM_SUBSCRIBER_LOCATION 1540 to the CPM

22   414 indicating that the mobile unit 112 is operating locally. The remaining message

23   flows 1541 - 1595 are similar to those shown in Figure 49.

24   Figure 68 shows the message flows associated with an incoming call to a

25   mobile unit 112 that is operating locally but is homed on an external HLR. The DHI

26   503 sends a CALL_RECEIVED 1600 to the CPM 414, which sends a CPM_IMH_

27   LOCATE_SUBSCRIBER 1602 to the IMH 432. Because the mobile unit 112 is not

28   homed locally, the IMH 432 sends a location request 1600/1608 to the external HLR

29   and sets (1604) a LOCREQ timer 1605. The IMH 432 then receives a return

1   1610/1612 from the external HLR and releases (1614) the LOCREQ timer 1605.

2   Then the IMH 432 sends an IMH_CPM_SUBSCRIBER_LOCATION 1616 to the

3   CPM 414 indicating the location of the mobile unit's 112 HLR. The remaining

4   message flows 1620 - 1699 are similar to those in Figure 49.

5   Figure 69 shows the message flows associated with call processing for a

6   mobile termination in which the mobile unit 112 is homed on the HLR 424 but is

7   operating externally to the wireless network controlled by the aircore platform 200. In

8   this case, the mobile unit 112 will be registered on an external VLR. The CPM 414

9   receives a CALL_RECEIVED 1700 and sends a location request 1702 to the IMH

10   432. The IMH 432 sends a location request 1704 to the HLR 424. Because the

11   mobile unit 112 is registered on another wireless network, the HLR 424 sends a route

12   request 1706 to the IMH 432, which sends an invoke 1710 to the external VLR and

13   sets a ROUTEREQ timer 1709. The external VLR returns the results 1712 to the

14   IMH 432, and the IMH 432 releases the ROUTEREQ timer 1709. The IMH 432 also

15   sends an IMH_HLR_ROUTE_REQUEST_RESPONSE 1716 to the HLR 424 and the

16   HLR 424 returns a location response 1718. The IMH 432 then sends (1720) the

17   location of the mobile unit 112 to the CPM 414, which issues a MAKE_CALL 1722

18   to the roaming number provided by the external wireless network serving the mobile

19   unit 112. The process then proceeds through call alerting and call connection.

20   Figure 70 shows the message flows for call processing for a mobile terminated

21   call when the mobile unit 112 is homed on an external HLR and is operating

22   externally to the wireless network controlled by the aircore platform 200. The CPM

23   414 receives a CALL_REQUESTED 1730 from the DHD 501. The CPM 414 then

24   sends a CPM_IMH_LOCATE_SUBSCRIBER 1732 to the IMH 432. The IMH 432

25   sets a timer 1734 and sends an invoke message 1736 to the DH-7 510. The DH-7 510

26   sends 1736 the invoke message to the external HLR and receives (1738) a response.

27   The DH-7 510 then sends a results message 1739 to the IMH 432. The remaining

28   message flows are similar to those shown in Figure 69.

1   Figure 71 shows the message flows associated with call processing for a

2   mobile unit 112 homed on an external HLR but operating within the wireless network

3   controlled by the aircore platform 200. In this scenario, the mobile unit 112 receives a

4   call that goes initially to the MSC of the external wireless network. The call is then

5   routed to the wireless network controlled by the aircore platform 200. The MSC 210

6   receives an invoke message 1751 from the external HLR. The IMH 432 then sends a

7   route request 1752 to the VLR 422. Because the mobile unit 112 is roaming, it will be

8   registered on the VLR 422. The VLR 422 returns a route request response 1753 to the

9   IMH 432, which sends a roaming number 1754 to the external HLR indicating the

10   location of the HLR 424. The remaining message flows are similar to those in Figure

11   49 with the exception that the IMH 432 does not have to locate the mobile unit.

12   Figure 72 shows the message flows associated with hand off pre-processing

13   for an ISDN PRI+ protocol. The BSC 105 sends a HANDOFF_REQUEST 1850 to

14   the DHI 503, which sends a HANDOFF_REQUEST 1852 to the HOP 416. The HOP

15   416 returns a MEASUREMENT_REQUEST 1854 to the DHI 503, which sends a

16   HANDOFF_MEASUREMENT_REQUEST 1856 to the BSC 105. The HOP 416 also

17   sends measurement requests (1854'/1856') to all base stations capable of handling the

18   message traffic from the mobile unit for which the hand off is requested. The BSC

19   105 returns a HANDOFF_MEASUREMENT_RESPONSE 1858 to the MSC 210, and

20   a MEASUREMENT_RESPONSE 1860 is sent to the HOP 416. Other base stations

21   likewise return measurement responses (1858', 1860') to the MSC 210. The HOP 416

22   then proceeds with the handoff process. Figure 72 shows the initial message

23   responses for the ISDN PRI+ protocol. Other protocols use similar initial

24   measurement flows to establish a target base station for hand off.

25   Wireless customers can pay for their services in a variety of ways including an

26   annual subscription and on a monthly basis, for example. In both these cases, the

27   customer pays for the call actually made (air time) plus a periodic base fee.

28   Customers can also pay for wireless services in advance through a prepaid system.

29   Figure 73 is a logical diagram of an aircore prepaid rating system 2100. The aircore

1   prepaid rating system 2100 includes a data management module 2101, a rating

2   administration module 2102, a distributor data module 2103, and distributor rate plans

3   2110 through 2119. Thus, a distributor can have up to ten different rate plans. Each

4   customer can select one of the ten different rate plans for each distributor in the

5   aircore prepaid rating system 2100.

6   The distributor can be viewed much like a class of service is viewed in

7   routing. The distributor is a classification of rating service that is assigned to certain

8   groups of subscribers in the aircore system. A distributor could be a point of sale, a

9   corporate customer, or an operator classification for a group of customers. Within

10   each distributor, there can be up to ten different rate plans configured. A rate plan

11   establishes the air time rates for the plan. The combination of distributor and rate plan

12   provide a comprehensive rating schedule for a variety of combinations within the

13   system.

14   Within each customer profile 460 (see Figure 20) in the aircore HLR 424, the

15   parameter for prepaid service is configured as prepaid or not. The prepaid

16   configuration of the customer is controlled via a prepaid check box and associated

17   prepaid window and a graphical user interface (see Figure 89). The window is used to

18   define the distributor and rate plan that the customer uses for the prepaid service.

19   Also, the credited amount for the account is input with the prepaid data. This field

20   tracks the amount of service that a customer is allowed on the system. The amount is

21   updated in real-time to track the usage of the system by the customer.

22   A third part of the prepaid system is bill generation that is integrated as part of

23   a call record management subsystem. The set of functions available allows the

24   operator the ability to create a range of reports based on operator defined billing

25   cycles.

26   In operation, when a customer who has elected a prepaid plan uses the aircore

27   prepaid rating system 2100, the customer profile 460 is pulled from the HLR 424 to

28   determine the applicable distributor rate plan. The information from the customer

29   profile 460 is passed to the CPM 414. The CPM 414 determines if the customer has

1   an account balance sufficient to pay for the call. The CPM 414 also determines the

2   least cost route for the call, including defining the land charge and the air time charge

3   associated with the destination and time of day of the call to come up with the per

4   minute charge. This value is then used to set a timer that will indicate when the

5   customer's account reaches a balance that corresponds to two minutes left on a call.

6   Once the prepaid call has begun, the timer begins a time out process and when

7   the two minute position is reached, a tone warning is provided to the customer

8   indicating that the customer is running out of money. No further warnings are

9   provided, and once the next two minutes have expired, the TMR 437 sends a message

10   to the CPM 414 indicating that the time has expired. The CPM 414 then initiates a

11   call cutoff, terminating the prepaid call. In this way, the customer cannot overrun the

12   prepaid account balance

13   At the completion of the call, the billing system 260 calculates how much the

14   call actually cost for the customer and updates the amount in the HLR 424. A call

15   detail record (CDR) is prepared that provides the detailed information regarding the

16   call so that the billing system 260 can determine the remaining account balance. The

17   bill generated by the billing system 260 is then used to update the customer profile

18   460.

19   In the wireless environment shown in Figure 1a-1d, there may be a need to

20   locate customers who place distress, or emergency (911), calls. These 911 calls are

21   used to gain rapid access to local authorities and emergency service centers. if a

22   customer places a 911 call from a wired device, locating that customer is easy using

23   call tracing procedures. Customers using wireless devices are more difficult to locate.

24   The air core platform 200 solves the problem of wireless customer location by

25   creating an identification number based on the current position of the customer in the

26   wireless environment. The aircore platform 200 uses the identification number as the

27   dialed number to route the call to an emergency service center. The identification

28   number includes the position data available from the BSS where the call origination is

29   received. The location information received from the BSS is coded in hexadecimal.

1   The aircore platform 200 converts the hexadecimal number to binary coded decimal

2   (BCD) and uses this number as an indication of the customer's location.

3   Following is an example of the data conversion used by the aircore platform

4   200 to convert the location data received from the BSS 110 to a dialed number for

5   emergency callers. The data received could be as shown in the following table in

6   which the BSS 110 receives the location of a customer with cell ID granularity. The

7   MSC 210 converts the data as shown in the table.

FIELD	RESULTING NUMBER OF DIGITS
Mobile Country Code	Up to 3
Mobile Network Code	Up to 3
Location Area ID	Up to 3
Cell ID	Up to 3

13   The numbers produced from the conversion yields a unique 12 digit number

14   identifying that cell in the system.

15   The aircore platform 200 may incorporate the concept of customer groups to

16   define the routing translations (classes of service) for the wireless network. A

17   customer group is a table of number ranges that is used to determine if a call is

18   allowable. The aircore platform 200 searches the list of entries in the table. If a

19   match is found, the call is allowed to proceed. If a match is not found, the call is not

20   allowed to proceed in the wireless network.

21   The aircore platform 200 allows for the definition of up to 256 different

22   customer groups. Each customer in the system, and each trunk, is associated with a

23   customer group when a customer group is initially configured. The customer group

24   that is used for a particular call is determined based on: 1) the customer placing the

25   call; and 2) the trunk that received the call.

1   For emergency calls, a specific customer group is used to provide the routing

2   translations. For emergency calling, the aircore platform 200 uses emergency

3   translations.

4   Figure 74 is a flow diagram illustrating emergency call processing using the

5   aircore platform 200. The processing starts as step S100. In step S110, the call is

6   received at the aircore platform 200. The process then moves to step S120. In step

7   S120, the aircore platform 200 determines if the call is an emergency call. If the call

8   is not an emergency call, the process proceeds to step S130 and the call is handled as a

9   normal call. In step S120, if the call is an emergency call, the process moves to step

10   S140. In step S140, the aircore platform 200 converts the location of the mobile unit

11   to a dial-up number. The process then moves to step S150.

12   In step S150, the aircore platform 200 checks the portion of the customer

13   group associated with emergency calls. The process then moves to step S160. In step

14   S160, the aircore platform 200 determines if the dial-up number from step S140 is in

15   the customer group. If the dial-up number is not in the customer group, the process

16   proceeds to step S170, and the call is routed to a default emergency center. If the dial-

17   up number is the customer group, the process moves to step S180. In step S180, the

18   aircore platform 200 changes the dial-up number to an emergency center number. The

19   process then moves to step S190. In step S190, the call is routed to the emergency

20   center. The process then moves to step S200 and ends.

21   The aircore platform 200 can also support other communication features. For

22   example, the aircore platform 200 may be used with a long-distance resale system.

23   The aircore platform 200 can also be used to provide microcellular wireless

24   networks in combination with land-line local networks or private branch exchanges

25   (PBX). There are several standards including computer supported

26   telecommunications applications (CTSA), windows telephony application

27   programming interface (TAPI), and telephony services application programming

28   interface (TSAPI), for example, that allow a PBX to incorporate equipment and

29   features from outside vendors. These protocols also allow for call control and routing

1   decisions to be made by a system that is external to the PBX. The external system can

2   be used to allow for connectivity, feature processing, and seamless number

3   management that allows customers to use both the PBX infrastructure and a separate

4   wireless system using one telephone number and one customer feature profile.

5   The aircore platform 200 provides an external control function to integrate a

6   wireless system, or microcell, and a PBX using the technique of third party call

7   control. Figure 75 is a diagram illustrating first party call control. In Figure 75, an

8   application 2010 controls a call from a PBX 2011 to a telephone 2014. The control of

9   the call is related to each of the signals and messages passed between the telephone

10 2014 and the PBX 2011. First party call control is often used as a call control feature

11 in private branch exchanges.

12 Figure 76 illustrates third party call control. In Figure 76, a call control

13 application 2015 provides direct control over termination of a call to the resource such

14 as the telephone 2014. Calls into a PBX 2016 are routed under the control of the call

15 control application 2015. The aircore platform 200 can incorporate the concept of

16 third party call control to add on to the functionality of a PBX. In particular, the

17 aircore platform 200 may be used with a PBX to add in-building wireless

18 communication capabilities to an existing wired private branch exchange.

19 A standard PBX interface control element (SPICE) may be added to the

20 aircore platform 200 to provide an interface to a PBX. The SPICE includes software

21 that can operate with the control protocols of different PBXs. The SPICE interfaces

22 internally with the HLR 424 and the SCR 314 (see Figure 10). A system operator may

23 interface with the SPICE using a graphical user interface (GUI).

24 The SPICE provides third party call control messaging needed to provide the

25 notice of an incoming call, decide how to handle the incoming call and send the

26 appropriate commands to route the incoming call to the correct destination. The

27 SPICE may be co-located with the HLR 424, and requires the basic retrieval

28 capabilities of the HLR 424. The customer profile information in the HLR 424 allows

29 the SPICE to determine how to handle a call. For example, the customer profile may

1   indicate the operational modes for the customer's wired and wireless telephone

2   handsets.

3   Customers whose PBX incorporates wireless features, including the SPICE,

4   noted above, may designate one or more operational modes for their telephone

5   handsets. Customers may elect to have incoming call terminate at their desktop

6   telephone first. If the desktop telephone is not available, the call may be routed, via a

7   MSRN, to the customer's mobile unit. Second, the call may be first routed to the

8   mobile unit. If the mobile unit is not available, the call may be routed to the desktop

9   telephone. Third, the call may be routed to the customer's mobile unit only. Fourth,

10 the call may be routed to the customer's desktop telephone only. Fifth, the call may

11 be routed to the mobile unit only when operating in the mobile unit's 112 home area.

12 One advantage of this arrangement is that the HLR 424 may house the full

13 suite of call forwarding features, voice mail and announcements. The customer's

14 profile determines how the call is handled.

15 If the customer profile indicates that incoming calls are first routed to a mobile

16 unit, the HLR 424 will locate the customer in the telecommunications network and

17 then have an MSRN allocated to deliver the call to the switch where the customer's

18 mobile unit is residing.

19 If the customer profile lists the desktop telephone as the first call delivery

20 option, the SPICE determines that the call should be terminated to the desktop

21 telephone. If the customer answers the desktop telephone, SPICE's involvement in

22 the call ends. However, if the customer does not answer at the desktop telephone,

23 SPICE processing can determine the appropriate handling for the call. The call could

24 be routed to the mobile unit, voice mail, or an announcement, for example.

25 Figures 77 - 79 illustrate call routing for various call entry points. In Figure

26 77, a PBX 2020 receives an incoming call from a PSTN (not shown). The PBX 2020

27 uses third party call control over a CSTA interface (not shown) to notify (2022) a

28 HLR 2030 that a customer has received an incoming call 2021. The HLR 2030

29 determines that the customer is currently roaming on another wireless telephone

1   system, and that the call needs to be delivered to the customer. Using standard mobile

2   application messaging, the appropriate number for the delivery is allocated and sent

3   (2023) to the PBX 2020. Via the CSTA interface, the PBX 2020 is commanded to

4   send the call over the PSTN with the delivery number as the destination. The call

5   arrives at a local MSC 2025 and is delivered (2037, 2038) via a wireless network 2035

6   to a mobile unit 2036.

7   Figure 78 shows a scenario for call delivery to the mobile unit 2036 when the

8   local MSC 2025 is the point of entry for the call from the PSTN (not shown). An

9   incoming call 2040 is received from the PSTN at the local MSC 2025. The MSC

10   2025 communicates (2041) with the HLR 2030 for call delivery information. The

11   HLR 2030 determines that the customer is roaming on another wireless network 2035

12   and that the call should be delivered to the wireless network 2035. The appropriate

13   number for delivery is allocated and sent (2039) to the MSC 2025. The MSC 2025

14   then delivers (2042, 2043) the call to the mobile unit 2036.

15   Figure 79 shows a scenario for call termination to a desktop telephone. In

16   Figure 79, the local MSC 2025 receives an incoming call 2045 from the PSTN (not

17   shown). The MSC 2025 communicates with the HLR 2030 for call delivery

18   information. The HLR 2030 determines that the customer is not registered in the

19   wireless network 2035 and determines that the call should be terminated to the PBX

20   2020. The HLR 2030 allocates (2047) a delivery number for the PBX 2020. Using

21   standard procedures, the HLR 2030 sends the delivery number to the MSC 2025. The

22   MSC 2025 then delivers (2048) the call 2045 to the PBX 2020. Using third party call

23   control, the HLR 424 associates the call 2045 with a customer and the call 2045 is

24   terminated to the desktop telephone 2014.

25   Figure 80 shows an aircore platform 2200 that is used to provide an in-

26   building wireless and wired telephone system with third party call control. A building

27   2210 includes a PBX 2211. The PBX 2211 connects to wired telephones 2212. The

28   building 2210 also includes a microcellular wireless network 2201 serving mobile

29   units 2213. The PBX 2211 connects to the aircore platform 2200 via wired a

1   connection and a suitable interface such as a RS-232 interface. The aircore platform

2   2200 includes a base station controller 2206 and a suitable interface to provide

3   wireless communication to the microcellular network 2201. The BSC 2206 may be

4   incorporated as a component on a card in the aircore platform 2200. A separate

5   database 2205, containing information related to customers of the building 2210 may

6   be provided with the aircore platform 2200. Alternately, the data may be included in a

7   home location register in the aircore platform 2200. Finally, macro cellular systems,

8   such as the extended wireless network 2220 with cells 2221 and 2222 may exist

9   external to the microcell 2201.

10   In operation a customer using both a wired telephone 2212 and a mobile unit

11   2213 may specify, by entry in the database 2205, for example, which of the wired

12   telephone 2211 and mobile unit 2213 should receive a call. Thus, when a call comes

13   in to a particular customer, the aircore platform 2200 will determine which of the

14   wired telephone 2212 and the mobile unit 2213 to connect to first. The aircore

15   platform 2200 can be further instructed that when the mobile unit 2213 is active, or in

16   a power-on state, all calls should first be routed to the mobile unit 2213. If the mobile

17   unit 2213 does not respond after a certain number of rings, the incoming call can then

18   be routed to the wired telephone 2212. The microcellular network 2201 may also be

19   used for visitors to the building 2210. In this case, a visitor having a mobile unit may

20   have that mobile unit initiate a registration notification when the mobile unit enters

21   the microcellular network 2201. Then, any incoming calls to the visitor's mobile unit

22   will be routed through the aircore platform 2200 to the microcellular network 2201.

23   When a customer of the building 2210 transits from the microcellular network

24   2201 to the external wireless network 2220, a location update is performed that

25   deletes the customer's location in a VLR of the microcellular network 2201, and

26   initiates a registration notification with the mobile switching center of the external

27   wireless network 2220. In this way, the exact location of the mobile unit 2213 may be

28   maintained so that calls to a particular customer may be routed in accordance with the

29   customer's routing plan contained in a VLR/HLR or the database 2205.

1   In the arrangement described above, a particular mobile unit 2213 and wired

2   telephone 2212 may share a common telephone number. In an alternate arrangement,

3   the wired telephone 2212 and mobile unit 2213 may have different telephone

4   numbers.

5   A microcellular network, such as the microcellular network 2201, may also be

6   adapted for use in large buildings, such as indoor stadiums and convention centers. A

7   mobile switching center such as the aircore platform 2200 may incorporate multi-

8   protocol processing and base stations so that visitors to the convention center may use

9   mobile units inside the convention center regardless of the protocol established for the

10   mobile unit. The aircore platform 2200 may be configured to charge different rates

11   for different visitors to the convention center. People who work in the convention

12   center may be charged yet another rate for using mobile units in the convention center.

13   The aircore platform 200 may incorporate fault resilient features, which may

14   be particularly desirable for distributed wireless systems. The fault resilient hardware

15   architecture of the aircore platform 200 may be logically split into three layers as

16   shown in Figure 81. A hardware architecture 2300 includes a computing element

17   layer 2310. The computing element layer 2310 includes computing elements 2311

18   and 2312. The computing elements 2311 and 2312 are connected by an appropriate

19   communications medium such as an ethernet 2313. The ethernet 2313 may have a

20   capacity of 100 Mb or more, for example.

21   An input/output (I/O) processor layer 2320 includes I/O processors 2321 and

22   2322. The I/O processors 2321 and 2322 are connected by an appropriate

23   communications medium such as a 100 Mb ethernet 2323. The I/O processors 2321

24   and 2322 are both connected to each of the computing elements 2311 and 2322 by an

25   appropriate communications medium such as a 40 Mb fiber optic cable 2314.

26   A telephony interface processor (TIP) layer 2340 includes a plurality of

27   telephony interface processors (TIPs) 2341_1 - 2341_n. The TIPs 2341_1 - 2341_n are

28   connected by a dual rail ethernet 2343. The ethernet 2343 is also used to connect the

29   TIPs 2341_1 - 2341_n with the I/O processors 2321 and 2322.

1   The three layers described above comprise the three main processing areas of

2 the aircore platform 200. Communications between the three layers provides for a

3 variety of physical layouts and geographical configurations. For example, the fiber

4 optic connection between the computing element layer 2310 and the I/O processor

5 layer 2320 can be geographically separated by 1.5 kilometers or more. The TIPs

6 2341_1 - 2341_n can be spread geographically and remotely controlled via a centralized

7 computing element layer and I/O processor layer set. Thus, the aircore platform

8 architecture 2300 can be adapted to provide a large distributed wireless network with

9 centralized control or the layers can be co-located.

10   Figure 82 shows the logical construction of the computing element 2311 in

11 more detail. The computing element 2312 is identical to the computing element 2311

12 and therefore, only the computing element 2311 will be described. The computing

13 element 2311 includes a central processor 2315, a memory 2316 and a PCI-based

14 connector 2317 that couples the computing element 2311 to the I/O processors 2321

15 and 2322. Also shown is a memory 2318 that stores the software applications that

16 operate in the computing element 2311. The software applications are described with

17 reference to Figure 10. The memory 2316 may be a random access memory (RAM),

18 for example. The memory 2318 may be a read only memory (ROM), for example.

19   Figure 83 shows the logical construction of the I/O processor 2321 in more

20 detail. The I/O processor 2322 is identical to the I/O processor 2322 and therefore

21 only the I/O processor 2321 will be described. A PCI interface 2332 connects the I/O

22 processor 2321 to the ethernet 2314. A memory module 2326 includes a hard disk

23 2327, an interface slot 2328 for a CD-ROM, and an interface 2329 for a floppy disk.

24 A memory 2325 includes the programming to operate the I/O processor 2325. A

25 central processor 2324 controls operation of the I/O processor 2325. An ethernet

26 interface 2330 provides connections to the ethernet 2323 and to the dual rail ethernet

27 2343. A memory 2333 stores application programs executed by the I/O processor

28 2321. Finally, SS-7 interface modules 2334 and 2335 provide connections to systems

29 external to the aircore platform 200.

1   Figure 84 shows the logical construction of the TIP 2341_1. The other TIPs are

2 the same as the TIP 2341_1. A central processor 2344 controls operation of the TIP

3 2341_1. A memory 2345 includes the operating programs for the TIP 2341_1. A

4 memory 2348 includes the application programs under control of the TIP 2341_1. The

5 application programs are described with reference to Figure 10. An interface 2347

6 connects the TIP 2341_1 to the dual rail ethernet 2343. A memory module 2346

7 includes a hard drive 2349 and a floppy disk interface 2350. An external interface

8 module 2349 connects the TIP 2341_1 to systems external to the aircore platform 200.

9   Figure 85 shows another hardware embodiment of the aircore platform 2400.

10 In this embodiment, the aircore platform 2400 includes a 19-inch rack-mountable

11 chassis 2410. The aircore platform 2400 includes dual loadsharing power supplies

12 2420 and optional power supplies 2422. The chassis also includes dual mirrored SCSI

13 disk drives 2430 and optional drive bays 2432. An I/O processor board 2440 connects

14 to telephony boards slots 1-14 for telephony boards 2470-2485. Finally, the aircore

15 platform 2400 includes a removable fan tray 2490.

16   Figure 86 shows the I/O processor in more detail. The I/O processor board

17 2440 includes a processor 2441 that provides bus control for the telephony boards

18 2470-2485. The processor 2441 can be an advanced processor such as an Intel

19 Pentium™ family processor or other processor. The I/O board 2440 also includes a

20 scalable random access memory 2442. The I/O processor board 2440 provides on-

21 board PCI video 2443, IDE 2444 and SCSI drive controllers 2445, and multiple serial

22 I/O ports 2446. Also included are Ethernet connections 2447, floppy disk drives

23 2448, and PCMCIA slots 2449. The I/O processor board 2440 provides front and rear

24 access to the I/O devices. The SCSI drives 2445 may be dual mirrored 1.5 Gb hard

25 drives. The SCSI drives 2445 may be configured in a RAID-1 format. The SCSI

26 drives 2445 are hot swapable and can be resynchronized in case of failure.

27   The aircore platform 2400 may provide for local network connectivity and

28 dial-out access using a standard 10base-T or 100base-T Ethernet connection for LAN

29 connecting options and a 56k dial-up modem for remote access dial-in capability.

1 Other advanced telecommunications connection devices may also be used with the

2 aircore platform 2400. Standard telephony boards may be used with the aircore

3 platform 2400 for T-1/E-1 and ATM communications. For example, the telephony

4 boards 2470-2485 include TH-B1240 OCTAL T-1/E-1 interface boards for common

5 channel signaling based T-1s. TH-BD96 quad T-1 interfaces are provided for channel

6 associated signaling using T-1s. TH-BD120 quad E-1 interface devises are used for

7 channel associated signaling using E-1s. TH-BV30 voice I/O provides 30 ports of I/O

8 and signal processing. TH-BC64 provides conferencing capabilities. A TH-BSS7

9 board provides both DS0 and V.35 connections. Each of the telephony boards 2470-

10 2485 provides 4-6 trunk links. Also connected to the aircore platform 2400 are

11 operator interface devices including a monitor 2491, a keyboard 2492, and a mouse

12 2493.

13 The switching architecture of the aircore platform 2300 or 2400 may be the

14 H.110/H.100 based standard, for example. The H.110 and the H.100 switching matrix

15 is a standard Application Specific Integrated Circuit (ASIC) that resides on each board

16 in the system. This means that rather than shipping all interface channels to a single

17 point in the system to make and break the connections for switching, each board

18 controls its own switching. The H.110 switching matrix uses a J4 connector or

19 connects to the other components of the aircore platform 2400 using a J4 connector on

20 a back plane of the chassis 2410. There may be a total of 32 streams running at

21 speeds of 8MH$_z$. Each stream provides 128 channels of 64 kbps. Total bus capacity

22 ranges from 512 to 4096 channels.

23 The H.100 switching matrix uses a ribbon cable to connect to boards together

24 to provide the actual streams of digitized channels. There are a total of 32 streams

25 running at speeds of 2MH$_z$ to 8MH$_z$. Each stream provides from 32 to 129 channels

26 of 64 kbps. The total bus capacity ranges from 512 to 4096 channels.

27 Other switching matrices may also be used with the aircore platform 2400.

28 The capacity of the aircore platform 2400 may be extended. Multi-chassis

29 configurations can be provided to claim the switch matrices together. This may be

1 accomplished using several standard multi-chassis interconnection interfaces or by

2 connecting the chassis via E-1 or T-1 connections. The addition of ATM allows for a

3 standard extension mechanism to the switch matrix between chassis.

4   Other hardware configurations besides the two embodiments described above

5 are available with the aircore platform 200.

6   The aircore platform 200 incorporates graphical user interfaces (GUIs) to aid

7 operator manipulation of system data. Figures 87-119 show the hierarchy of windows

8 used with the GUIs and also show examples of GUI screens used with the aircore

9 platform 200.

10   Figure 87 shows the hierarchy of windows used with the aircore HLR 424. A

11 hierarchy 3000 includes a home location register icon screen 3001 which is initially

12 displayed. Upon entry of a password in a password screen 3002, a home location

13 register access screen 3003 is displayed. Using the home location register access

14 screen 3003, an operator can choose one of the screens 3004-3009 for GSM, CDMA,

15 TDMA, AMPS, multi-mode protocols, or for prepaid services. Finally, corresponding

16 to each of the wireless protocols is a separate prepaid screen 3010-3014.

17   GSM subscriber profiles are configured as per the GSM feature set. CDMA

18 subscriber profiles are configured as per the CDMA (IS-664) feature set. Multi-mode

19 subscriber profiles may be configured for multiple air interfaces. Multi-mode

20 subscribers use the common feature set between the GSM, CDMA, TDMA and

21 AMPS protocols. All of the above subscriber profiles can incorporate prepaid feature

22 functionality.

23   Prepaid subscriber profiles are configured as strictly prepaid in the aircore

24 system. Prepaid subscribers may use wireless or wireless prepaid features.

25   Figure 88 shows the GSM subscriber window 3004 in more detail. A number

26 of subscribers block 3021 lists the current number of subscribers in the HLR 424 as

27 well as the capacity of the HLR 424. The subscriber list 3022 individually lists the

28 subscribers to the aircore systems. A previous button 3025 and a next button 3026

29 loads the previous or next group of subscribers into the subscriber list scroll box 3022.

1   A properties button 3023 allows modification of data for the selected subscriber. A

2   search button 3024 allows for search of the HLR 424 when a subscriber MSISDN

3   number is input at the search line. An add button 3027 and a delete button 3028 allow

4   the addition or deletion of a subscriber profiled in the HLR 424. A report button 3029

5   allows an operator to view a change report file created for HLR 424 modifications.

6   Figure 89 is an example of an individual subscriber profile for a GSM

7   subscriber. The subscriber profile 3030 includes a customer and mobile unit

8   identification block 3031, call offering block 3032, call restriction block 3033, and

9   call restrictions block 3034. Also included is a call features block 3035, and line

10   identification block 3036.

11   Subscriber profiles for other wireless protocols are similar to that described

12   above for a GSM subscriber.

13   Figure 90 shows a routing administration windows hierarchy 3110 associated

14   with establishing routing translations in the aircore systems. The initial screen is a

15   database management icon screen 3101. Next, a routing administration tab 3102 is

16   display. Linked to the routing administration tab 3102 is a customer group properties

17   screen 3103. Also linked to the routing administration tab 3102 is a standard routing

18   screen 3104, a feature codes screen 3105, an emergency call routing screens 3106 and

19   a tones and announcement screen 3107. The data displayed in the screens 3104-3107

20   may be modified by displaying an add/modified/delete screen 3108.

21   Figure 91 shows the routing administration tab 3102. A customer group scroll

22   box 3111 shows the customer groups that are currently active in the aircore system.

23   The customer group is a required piece of data that is assigned to both customers and

24   trunk groups. The number assigned is used as an index into the appropriate routing

25   table for processing an incoming call. The routing translations determine the

26   allowable calls, the type of call, and the appropriate system routing for the call. Each

27   customer group can accommodate hundreds of individual from-to routing translation

28   entries. The translations can provide support for any dialing plan between 1 and 32

29   digits. Dialing plans of varying lengths maybe configured within the same customer

1   group. Each line of translations within each customer group provides a primary and

2   alternate route based on the trunk group. In addition, each route is provided its own

3   digit manipulation parameters (strip and prefix digits). The aircore system can

4   accommodate up to 100 customer groups.

5   Figure 92 shows a customer group modification window 3120. The customer

6   group modification window 3120 defines the overall properties associated with a

7   particular customer group. Check boxes 3121 allow for the configuration of three

8   alternate types of translations.

9   Figure 93 shows the standard routing translation window 3104. A scroll box

10   3131 is used to display portions of the information. The information displayed in the

11   scroll box 3131 includes "from" data, which is the number the range starts from; "to"

12   data, which is the number the range ends at; min, which is the minimum length of the

13   digit string; max, which is the maximum length of the digit string; and type, which is

14   the type of call the number range indicates. Also shown is the route number of the

15   trunk and the numeric trunk group number.

16   Figure 94 shows the standard routing translations modifications window 3108.

17   The standard routing translations modifications window 3108 provides the operator

18   access to modify the selected number range. The window is used for adding or

19   modifying ranges in the standard routing translations window 3104.

20   Figure 95 shows the feature code routing translation window 3105. The

21   feature code routing translation window 3105 includes a scroll box 3151 that displays

22   a portion of the information selected by the operator. The feature code routing

23   translation window 3105 contains the information related to routing feature

24   manipulation calls for the aircore system. The parameters supplied in the feature code

25   routing translation window 3105 are used to determined the type of feature

26   manipulation and the appropriate system action.

27   Figure 96 shows the emergency call routing translations window 3106. A

28   scroll box 3161 displays currently selected information. The information includes

29   "from" data which is the number the digit range starts from. The "from" data can be

1   indicated by a code such as 911 or can be represented as a cell site. The aircore

2   system operator can use the emergency call routing translations window 3106 to route

3   all emergency calls to a specific number or to establish a trunk group used exclusively

4   for emergency call routing.

5   Figure 97 shows the treatment routing translations window 3107. The

6   treatment routing translation window 3107 contains information relate to routed calls,

7   which are to be treated to an appropriate treatment option, which may be a tone or

8   announcement. In Figure 97, a scroll box 3171 includes an ID, which is the number

9   of the treatment in the aircore system, a description 3172, which is the alpha-numeric

10   description of the treatment, a first option (1st Route) 3173, which is the first option

11   for treating the call (typically configured to an announcement or tone) and a second

12   option 3174, which is the second option to use if the first option 3173 is not available

13   (typically set to a standard tone). Failure to use the first option 3173 indicates that all

14   of the announcement resources are currently in use.

15   The aircore system includes graphical user interfaces that allow the operator to

16   perform maintenance actions on individual trunks in the system. When this option is

17   chosen in an administration pull down menu (not shown), the operator first selects the

18   appropriate span and channels, then executes maintenance commands as required.

19   Figure 98 shows the hierarchy of windows used for trunk maintenance. In Figure 98,

20   the hierarchy 3200 includes a control panel window 3201, an administration window

21   3202, a facilities selection window 3203, and a digital trunk maintenance window

22   3204.

23   Figure 99 shows the facilities selection window 3203. The window 3202

24   allows an operator to select the appropriate facilities in the aircore system to be

25   viewed for maintenance actions.

26   Figure 100 shows the digital trunk maintenance window 3204. The digital

27   trunk maintenance window 3204 allows the operator to view the trunk configuration

28   of a particular span and to change the state of the channels on that span. In the

29   window 3204, data that is grayed out represents non-configured channels. Channels

1   can be configured via a system configuration option on the administration pull-down

2   menu. Figure 100 shows the digital trunk maintenance window for T-1 trunk

3   maintenance. A similar window is available for E-1 trunk maintenance.

4   Figure 101 shows the aircore configuration windows hierarchy 3300. The

5   system configuration 3301 is accessed from a control panel graphical user interface

6   (not shown). This allows the operator to access setup and configuration files. The

7   operator has access to the configuration of both hardware and software parameters

8   associated with system operation. Subordinate windows in the system configuration

9   hierarchy 3300 include a trunk group window 3302 and a board configuration window

10   3303. Associated with the trunk group window 3302 is a trunk group configuration

11   window 3304. Associated with the board configuration window 3303 is a T-1/E-1

12   board configuration window 3305, a voice I/O window 3306, a conference window

13   3307, a SS7 window 3308, and an analog window 3309 and span configuration

14   windows 3310 and 3312.

15   Trunk group configuration is part of the system configuration of the aircore

16   GUI. A trunk group is a logical assignment of characteristics to physical resources in

17   the aircore system. Trunk groups are used to inform both the low level and high level

18   software in the aircore system of how to process a call. Trunk groups also allow the

19   operator to partition the system for specialized use by groups or subscribers. Figure

20   102 shows the trunk group selection window 3302. A properties button 3322 is used

21   to access the trunk group configuration window 3304.

22   Figure 103 shows the trunk group configuration window 3304. When a valid

23   trunk group number is input in the selection window 3302, and the property button

24   3322 is pushed, the configuration window 3304 appears. The trunk group

25   configuration window 3304 includes the sequential number assigned to the trunk

26   group and an alpha-numeric name associated with the trunk group. The name given to

27   the trunk group is used to identify the individual circuits configured within the trunk

28   group.

1   Figure 104 shows the board configuration window 3303. The aircore board

2   level configuration is accomplished via the board configuration window 3303 and

3   subordinate windows. The board configuration window lists the possible board slots

4   in the hardware component (installed or not) in a particular slot. To access the

5   configuration of the particular board, the operator selects a desired board and operates

6   the property button 3332.

7   Figure 105 shows the T-1/E-1 board configuration window 3305. A span click

8   box section 3381 allows an operator to choose which span to configure. The window

9   3305 is used for configuration of the T-1 and E-1 boards in the aircore system. Based

10   on the board type selected, the appropriate number of spans and channels are

11   accessible to the operator for configuration. The window shown in Figure 105 is used

12   for configuration of the 4-span T-1 board, for the CPCI and PCI bus types. Similar

13   windows are used for other span and channel configurations.

14   Figure 106 shows the T-1/E-1 span configuration window 3310. The T-1/E-1

15   span configuration window 3310 appears when a span (A-H) is selected from click

16   box 3381 in the T-1/E-1 board configuration window 3305 shown in Figure 105. The

17   window 3310 contains the data associated with a particular T-1 or E-1 span on the

18   board. Similar windows are available for other span configurations.

19   Figures 107-109 show the windows for the voice I/O board configuration, the

20   conference board configuration, and the SS-7 board level configuration. These

21   windows are similar to that shown in Figure 106.

22   The aircore system generates call detail records (CDRs) to track system

23   resource usage and call traffic for customers. Each CDR contains information

24   pertaining to a particular part of a call. A CDR is a record created whenever there is

25   call activity on the aircore system. The CDR manager is a subsystem in the aircore

26   system responsible for generating and storing this information. The CDR manager

27   provides the operator with a complete set of options for viewing data both real time

28   and archive, monitoring traffic on the aircore system, and retrieving the data for off-

29   system archival. Figure 110 shows the hierarchy of windows used for call record

1   management. The hierarchy 3500 includes the call record manager window 3501,

2   archive window 3502, configuration window 3503, and billing window 3504. The

3   billing window 3504, and associated lower level windows, are only available if the

4   prepaid wireless package is configured. Associated with the configuration window

5   3503 are output selection window 3507 and auto removal window 3508. Associated

6   with the billing window 3504 is distributor selection window 3506 and bill generation

7   window 3509. The call record manager window 3501 provides operator access to

8   view, process or redirect call detail record outputs on the aircore system.

9   Figure 111 shows the archive window 3502. The archive window 3502 allows

10   the operator to view and direct archived output of call detail records that have been

11   created on the aircore system.

12   Figure 112 shows a configuration window 3503. The configuration window

13   3503 allows the operator to determine the real time output destination for call detail

14   records. Regardless of the output type selected, a file containing the call records on

15   disk is always created. In addition, the operator has the ability to configure the auto

16   removal period for the call detail records. Using the output selection window 3507,

17   the operator can send an output to a display or a printer, for example.

18   Figure 113 shows the auto removal window 3508. Using the auto removal

19   window 3508, the operator can set the number of days that the call detail record will

20   be archived on the system. The number of days the call detail records are stored on

21   the aircore system before automatic removal can be set a value between 1 and 180 in

22   increments of one day.

23   The aircore platform 200 can provide, as an option, fully integrated prepaid

24   functionality. This functionality can span across both wireless and wireline

25   applications providing a seamless prepaid system. Furthermore, this functionality is

26   provided as an integrated software feature, saving the cost and maintenance of a

27   separate off-board prepaid system. The prepaid system feature package provides full

28   functional real time debiting for aircore customers complete with a full billing

29   package and a comprehensive rating schedule. Figure 114 shows the rating

1   administration window hierarchy 3600 that is used in conjunction with the aircore

2   prepaid system. A database management icon screen 3601 is shown initially. Next, a

3   rating administration window 3602 is displayed. A distributor data window 3603 and

4   a distributor properties window 3606 can be selected from the rating administration

5   window 3602. Finally, from the distributor data window 3603, an add/modify/delete

6   rate window 3605 can be accessed as well as individual rate plans 0-9 360 $_{i\text{-}n}$ with

7   associated add/modify delete rate windows 3607 $_{i\text{-}n}$. The aircore prepaid system

8   accommodates ten rate plans.

9   Figure 115 shows the rating administration window 3602.

10   Figure 116 shows the add/modified/delete rate window 3605. A distributor

11   number box 3621 shows the number assigned to a distributor when added to the

12   system. A default rate plan box 3622 shows the rate plan used as the default for

13   subscribers added for the distribution shown in the distributor number box 3621. The

14   default rate plan is used when a rate plan is not explicitly assigned. A description

15   window 3623 provides the name and/or a description of the distributor shown in the

16   distributor number box 3621.

17   Figure 117 shows distributor data modification window 3603. The distributor

18   data modification window 3603 allows for the configuration of the land charges rate

19   plans used for real time billing on the aircore system. The window 3603 is accessed

20   on a per distributor basis. Distributor data includes access to land charges and

21   configured access to rate plans. In addition to a default rate plan, each distributor can

22   have up to ten different rate plans. Each rate plan specify specific air time rating

23   structures. Land charges are specified on a per distributor basis.

24   Figure 118 shows a rate plan window 3607. From the distributor data

25   modification window 3603 shown in Figure 117, if an active rate plan button is

26   selected, the rate plan window 3607 appears. The rate plan window 3607 provides the

27   operator with the ability to configure the air time charges associated with a specific

28   rate plan. The rate plan window 3607 also provides the ability to specify any

29   exceptions to the main distributor land based charges. Data specified in the rate plan

1   window 3607 overrides the date in the distributor window 3603 and allows an

2   operator to specify unique plans for both land and air time rates without adding a new

3   distributor each time.

4   Figure 119 shows a country entry window 3640. The country entry window

5   3640 allows modification of rates charges for the land portion of the call. These

6   charges are based on a first and additional minute rate to each location around the

7   world.

8   Figure 120 shows a debit subscriber profile window 3650. The debit

9   subscriber profile window 3650 is used to input debit specific subscriber data for

10 accounts. The window 3650 is accessed via the debit button on a main subscriber

11 profile window (not shown). The fields of the window 3650 specify the parameters

12 used for real time billing and account information for the subscriber. The window

13 3650 opens as an overlay on the subscriber profile window and allows the subscriber

14 number, name, customer group and serial numbers to be viewed when editing the

15 debit subscriber profile window 3650. A balance section 3651 includes the current

16 amount, which is the current balance in dollars for the individual subscriber account.

17 This amount is incremented based on the subscriber usage. Subscriber access is cutoff

18 when the current amount is equal to the credit limit. The credit limit is the maximum

19 amount in dollars for the subscriber account. The credit limit is compared against the

20 current amount value to determine if access to the account is allowed. If the current

21 amount field equals the credit limit field, access to the account is not allowed. The

22 payment method field specifies the method of payment for the account. The payment

23 method can be cash, credit or other. If credit chosen, the credit card fields must be

24 filled in. The debit subscriber profile window 3650 also includes a credit card section

25 3652. The credit card section 3652 includes the credit card number (if applicable) the

26 type of credit card and the expiration date of the credit card. Other information

27 provided in the debit subscriber profile window 3650 includes the distributor and rate

28 plan and billing methods chosen for this customer.

1   The billing window 3504 (see Figure 110) provides access to customer billing

2   records. The billing window 3504 is accessed from the menu bar of the call record

3   manager window 3501. When selected, the distributor selection window 3506 shown

4   in Figure 21 is displayed. The distributor selection window 3506 allows an operator

5   to select a distributor for a billing calculation. The distributor selection window 3506

6   provides access to the billing generation window 3509.

7   The aircore system provides for the configuration of up to twenty different

8   language files for assignment to customers or for announcements. Figure 123 shows a

9   languages administration window 3680. The languages administration window 3680

10   provides operator access to a language configuration database in the aircore system.

11   The language configuration window 3680 is accessed from the database management

12   icon screen 3101 (see Figure 90).

13   Figure 122 shows the billing generation window 3509. The billing generation

14   window 3509 allows access to individual subscriber bills and invoices as well as

15   location summaries of customer usage. Billing information is accessed on the basis of

16   the location summoned.

17   While this invention has been described in conjunction with the specific

18   embodiment outlined above, it is evident that many alterations, modifications and

19   variations will be apparent to those skilled in the art. Accordingly, the preferred

20   embodiments of the invention as set forth above are intended to be illustrative, not

21   limiting. Various changes may be made without departing from the spirit and scope

22   of the invention as defined in the following claims.